JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS (DPWH)

PREPARATORY SURVEY FOR SOUTHERN MINDANAO ECONOMIC CORRIDOR IMPROVEMENT (DAVAO CITY BYPASS CONSTRUCTION) PROJECT

DRAFT FINAL REPORT

October 2014

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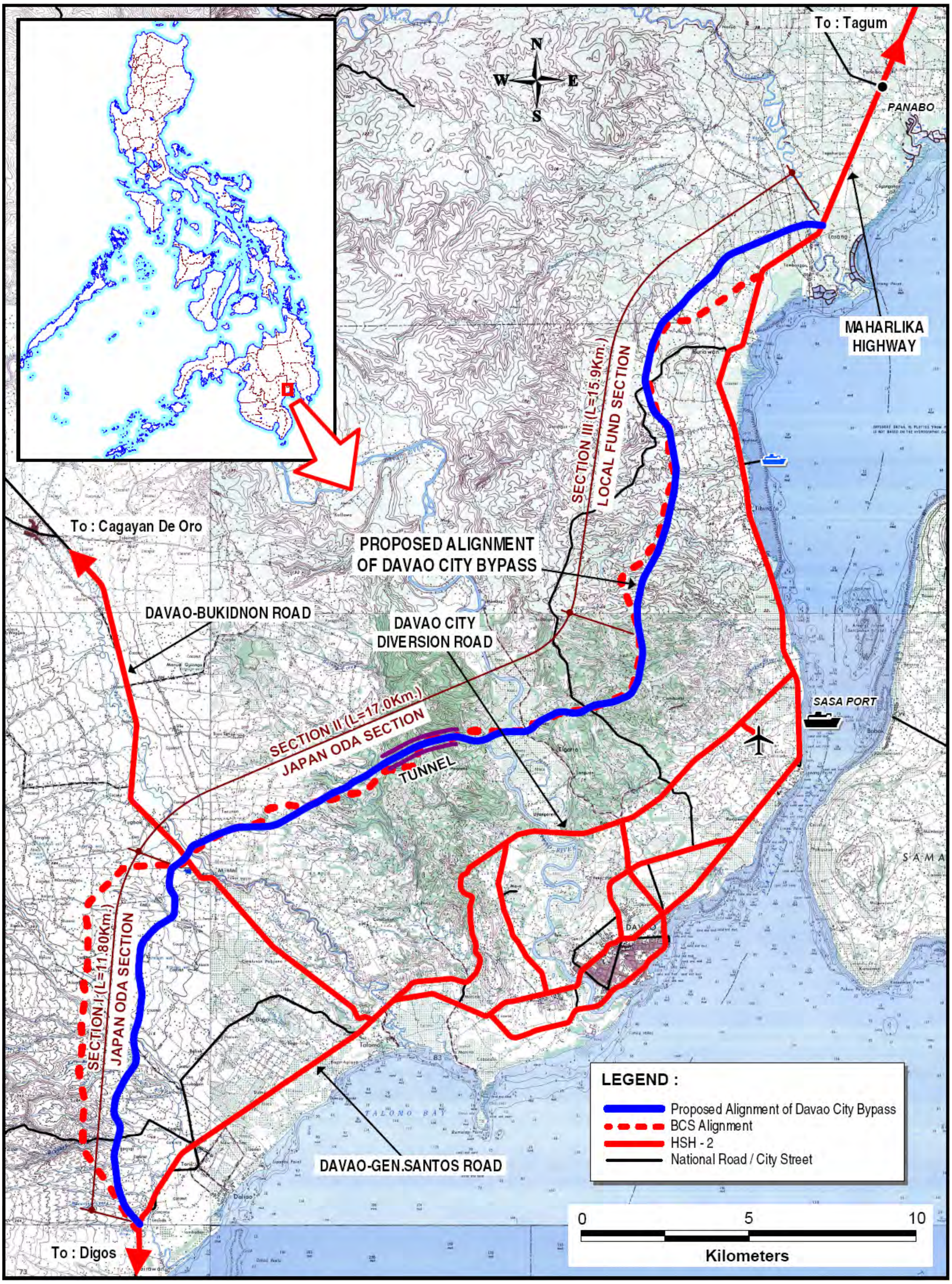


LOCATION MAP OF PROJECT AREA

ACRONYMS AND ABBREVIATIONS

AASHTO	:	American Association of State Highway and Transportation Officials
ADB	:	Asian Development Bank
ASEAN	:	Association of Southeast Asian Nations
BCS	:	Business Case Study
BPI	:	Bureau of Plant Industry
CLUP	:	Comprehensive Land Use Plan
DENR	:	Department of Environment and Natural Resources
DPWH	:	Department of Public Works and Highways
ECAs	:	Environmentally Critical Areas
ECC	:	Environmental Clearance Certificate
ECPs	:	Environmentally Critical Projects
EIA	:	Environmental Impact Assessment
EIS	:	Environmental Impact Statement
EMB	:	Environment Management Bureau
EO	:	Executive Order
GDP	:	Gross Domestic Product
GRDP	:	Gross Regional Domestic Product
HCM	:	Highway Capacity Manual
HSH Master Plan	:	High Standard Highway Master Plan
IEC	:	Information Education and Communication
IMF	:	International Monetary Fund
JICA	:	Japan International Cooperation Agency
LGUs	:	Local Government Units
MDG	:	Millenium Development Goals
MILF	:	Moro Islamic Liberation Front
MinDA	:	Mindanao Development Authority
NCIP	:	National Commission on Indigenous Peoples
NEDA	:	National Economic Development Authority
NTP	:	National Transport Policy
O-D	:	Origin-Destination
PCC	:	Portland Cement Concrete
PCU	:	Passenger Car Unit
PD	:	Presidential Decree
PDP	:	Philippine Development Plan
PDS	:	Project Description for Scoping
PEISS	:	Philippine Environmental Impact Statement System
PIP	:	Public Investment Plan
PPP	:	Public-Private Partnership
RAP	:	Resettlement Action Plan
RDP	:	Regional Development Plan
RORO	:	Roll-On Roll-Off
ROW	:	Right-Of-Way
SOCCSKSARGEN	:	SOuth Cotabato, Cotabato, Sultan Kudarat, SARangani, GENeral Santos City
STRADA	:	System for TRAffic Demand Analysis
WB	:	World Bank

Table of Contents

List of Table

Page

List of Figure

CHAPTER 1
INTRODUCTION

1.1 BACKGROUND OF THE STUDY

The Mindanao has for decades lagged behind the rest of the Philippines in terms of economic development despite its agro-fishery, mineral and human resources potentials. However, in recent years the region has been showing faster economic growth than the rest of the country, and the signing of the Bangsamoro Peace Framework Agreement between the government and the Moro Islamic Liberation Front (MILF) in October 2012 is expected to accelerate the recent economic development. Davao City, the third and the most major city in Mindanao, is expected to play a leading role in the economic growth. Major urban roads in Davao City have 4-lanes (2-lane per direction), but are insufficient to ease it severe traffic congestion. Similarly, traffic from and to Sasa and Panabo Ports is also frequently experiencing traffic congestion, affecting the transportation of goods. JICA conducted a Master Plan on High Standard Highway Network Development (July 2010), which proposed improvement of the Tagum-Davao-General Santos Corridor and the construction of a diversion road in Davao City as a priority project.

Road widening and improvement project of the above corridor is on-going for many parts of sections, such as four (4) lane widening of present two-lane section, and slope protection construction by World Bank and other funds.

Regarding Davao City Bypass project, the Department of Public Works and Highways (DPWH) conducted a Business Case Study (hereinafter referred to as BCS) and the study results, both economic and financial aspects was the basis to determine whether the Project is qualified for a PPP and/or as a conventional Government project.

DPWH is studying the utilization of Yen loan as one of candidate sources of funding in order to implement the Davao City Bypass Project. Both JICA and DPWH recognized that this Project is a very important project for traffic improvement in Davao City and Mindanao Eastside Area as agreed upon in the Minutes of Discussion on the contents of Preparatory Survey for the Project in 1 February 2013.

1.2 OBJECTIVE OF THE STUDY

The objective of the Study is to prepare all the data, information and document necessary for JICA to appraise the Davao City Bypass Project for Japan’s Yen Loan. Data, information and construction documents include the objectives of the Project, project scope of work, project costs, implementation organization, environmental and social consideration related documents, etc.

1.3 OBJECTIVE AND SCOPE OF THE PROJECT

Objective: To improve the transport logistics and mitigate congestion in Davao City, thereby contributing to economic and social development in Mindanao.

Scope: Davao City Bypass (Total of 30 ~ 40 km, **including** about 2 km Tunnel Section). (As for the Davao City – General Santos City Corridor, only the present condition, implementation program, fund sources, etc. will be confirmed.)

1.4 STUDY AREA

The Survey Area shall cover Region XI.

1.5 SCOPE OF THE STUDY

In order to achieve the above objective, the Study shall cover the following:

(1) Information collection on background and necessity of the Project
(2) Review of Previous Studies
(3) Study on Design Principles and Standards
(4) Engineering Surveys
(5) Preliminary Design/Construction Execution Plan/Construction Cost Estimate/ROW Acquisition Plan
(6) Environmental Impact Assessment
(7) Resettlement Action Plan
(8) Traffic Survey
(9) Traffic Demand Forecast
(10) Evaluation of the Project
(11) Operation and Maintenance Plan
(12) Project Implementation Organization and Overall Implementation Schedule
(13) Project Cost Estimate
(14) Survey on Procurement Conditions

CHAPTER 2
NATIONAL / REGIONAL DEVELOPMENT PLANS

2.1 PHILIPPINE DEVELOPMENT PLAN (2011-2016)

The Philippine Development Plan (PDP), 2011-2016, was launched in 2011. Under this Plan, development policies for infrastructure are as follows:

DEVELOPMENT POLICIES FOR INFRASTRUCTURE

"**Accelerating Infrastructure Development**"

(1) To optimize resources and investment
- Improve project preparation, development and implementation.
- Synchronize planning and budgeting.
- Coordinate and integrate infrastructure initiatives.

(2) To attract investments in infrastructure
- Improve the institutional and regulatory environment of the infrastructure sector.
- Encourage PPPs.

(3) To foster transparency and accountability in infrastructure development
- Encourage stakeholder participation.

(4) To adopt to climate change and mitigate the impacts of natural disasters
- Institutionalize Climate Change Act (CCA) and Disaster Risk Reduction Management (DRRM).

(5) To provide productive employment opportunities
- Adopt labor-intensive schemes where applicable.

With regard to the transport sector, issues and challenges are established as follows:

TRANSPORT SECTOR ISSUES AND CHALLENGES

(a) Assessment and Issues
- Lack of integrated and coordinated transport network.
- Overlapping and conflicting functions of transport and other concerned agencies.
- Transport safety and security concerns.

(b) Strategic Plan and Focus
- Adopt a comprehensive long-term National Transport Policy (NTP).
- Develop strategic transport infrastructure assets
  - Prioritize asset preservation.
  - Provide access to major and strategic tourism destinations and production areas.
  - Promote environmentally sustainable and people-oriented transport.

(c) Develop an Integrated Multi-modal Logistics and Transport System
- Identify and develop strategic logistics corridors based on a National Logistics Master Plan.
- Improve Roll-on Roll-off (RORO) terminal system.
- Explore ASEAN connectivity through sea linkages.

(d) Separate the Regulatory and Operation Functions of Transport and Other Concerned Agencies. Address the overlapping and conflicting functions of transport and other concerned agencies.

(e) Comply with Safety and Security Standards. Ensure transport safety and standards.

(f) Provide Linkages to Bring Communities into the Mainstream of Progress and Development. Promote development in conflict-affected and highly impoverished areas.

2.2 MINDANAO DEVELOPMENT PLAN 2020

Mindanao 2020, Peace and Development Framework Plan 2011-2030 was announced in 2011 by Mindanao Development Authority. This development plan described the necessity of infrastructure and logistics development in “Requisites for Realizing Mindanao 2020”.

> **Requisites for Realizing Mindanao 2020**
>
> **Vision**
> *Infrastructure, knowledge and financing support systems are well in place, effectively propelling a wide array of peace and development initiatives in Mindanao towards successful outcomes beneficial to all Mindanawons.*

Strategy that are specific to each infrastructure are the following sub-sector

- Transportation and Logistics System
- Information and Communications Technology Support
- Energy and Power
- Water Supply, Irrigation and Sanitation

“Transportation and Logistics System’s Strategy” is included below

- Widen the role of inland, coastal and inter-island water-based transport in the Mindanao transport and logistics system.
- Reform policies and regulations that have rendered the transport and logistics system inefficient and costly (e.g. cabotage law and high import tariffs on steel products), along with industries linked to them.
- Integrate land, air and water transport systems into a coherent and interactive array of interdependent networks.
- Upgrade main arterial roads into world-class all-weather highways, and build new ones where necessary (e.g. Mindanao’s east and west links).
- Promote alliances among LGUs and partnerships among government and community in the construction of municipal and barangay roads through the provision of an enabling legal environment and a system of incentives.
- Prepare a long-term plan for a railway system that is closely coordinated with the other infrastructure plans mentioned above, to complement the proposed inter-modal transportation and logistics superhighway.
- Prioritize the upgrading, expansion or modernization of existing airports, particularly the community airports located inland, and pursue construction of a state-of-the-art airport in the Mindanao heartland out of one of such existing inland airports.
- Strengthen implementation of policies on user payments for infrastructure facilities to address inefficiencies in resource mobilization and utilization.

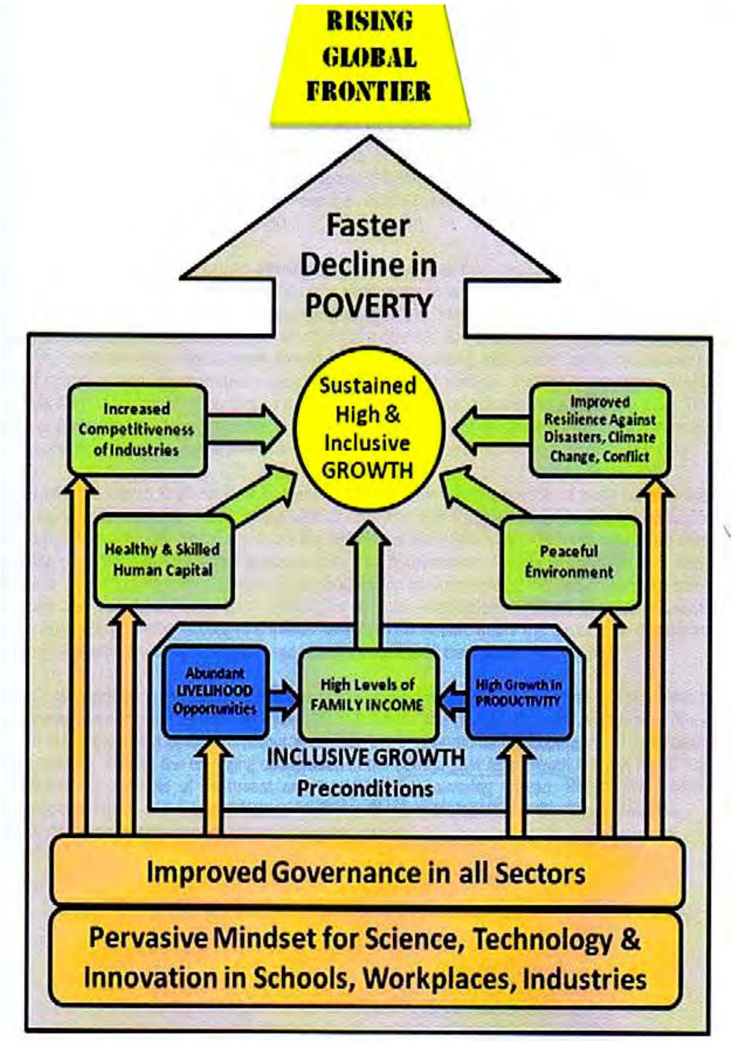
Davao City Bypass Project should be in harmony with the above strategy.

2.3 REGION XI REGIONAL DEVELOPMENT PLAN (2011-2016)

Davao Regional Development Plan (RDP) 2011-2016 was announced in 2011.

Goal and Objectives:
Aiming as the Nation's Rising Global Frontier, Davao Region shall focus in the goal of a faster decline in its poverty numbers by 2016.

Region's poverty incidence among families:
26.2% (Year2006) → 22.3% (2016)
To achieve above goal, the overall framework for Davao Region's development was prepared.



Source: Davao Regional Development Plan, 2011-2016

FIGURE 2.3-1 DAVAO REGIONAL DEVELOPMENT FRAMEWORKS

Sectoral Development Directions

The Davao RDP mentioned the following ten (10) sectoral development directions.

1. Macroeconomic Management
2. Modern and Competitive Agriculture
3. Competitive Industry and Service Sectors
4. Strategic and Sustainable Infrastructure
5. Science, Technology and Innovation
6. Good Governance
7. Human Resource Development
8. Peace and Development
9. Sustainable Environment and Resources
10. Social Protection for inclusive Growth

Strategic and Sustainable Infrastructure

"Need to improve access to and quality of infrastructure support."

RDP mentioned that "Davao Region still need to catch up in terms of construction of more or better quality roads in order to achieve high standard highway quality and internationally accepted road safety standards."

Davao City Bypass Project will realize the above target of RDP.

2.4 REGION XII REGIONAL DEVELOPMENT PLAN (2011-2016)

SOCCSKSARGEN Regional Development Plan 2011-2016 was announced in 2011.

SOCCSKSARGEN (or Region XII) is located in Central Mindanao. The region consists of four (4) provinces and one (1) city: South Cotabato, Cotabato, Sultan Kudarat , Sarangani and General Santos City.

SOCCSKSARGEN Vision of Development

"By 2016, Region XII is the home of God-centered and empowered, culturally diverse people, provider of world class high value crops, fishery, mineral and tourism products and services, propelled by dynamic and dedicated leaders and living in a green and healthy environment".

Development Goals and Strategic Outcomes

1) Inclusive Growth and Poverty Alleviation

- Achieving 7% Economic Growth by 2016
- Meeting the MDG Poverty Reduction Targets by 2015
- Management of Population Growth Rate
- Stabilizing Inflation Rate

2) Increased and Sustained Growth in Agriculture, Fishery and Industry.

- Boosting Agriculture and Fishery Production and Agriculture industrialization
- Development of High Impact Industries
- Propagating Micro, Small and Medium Enterprises (MSMEs)
- Science Technology (S & T)

3) Equal Access to Quality Basic Social Service

- Ensuring Universal Access to Quality Health Care and Sanitation
- Raising the Quality of Education and Training for Globally Competitive Human Resources
- Promoting Strong and Effective Social Protection Service
- Equal Access to Land and Land Rights
- Equal Access to Adequate and Safe Housing

4) Effective Infrastructure Support
- Integrated and Effective Transport System
- Efficient Water Resource Management
- Communication

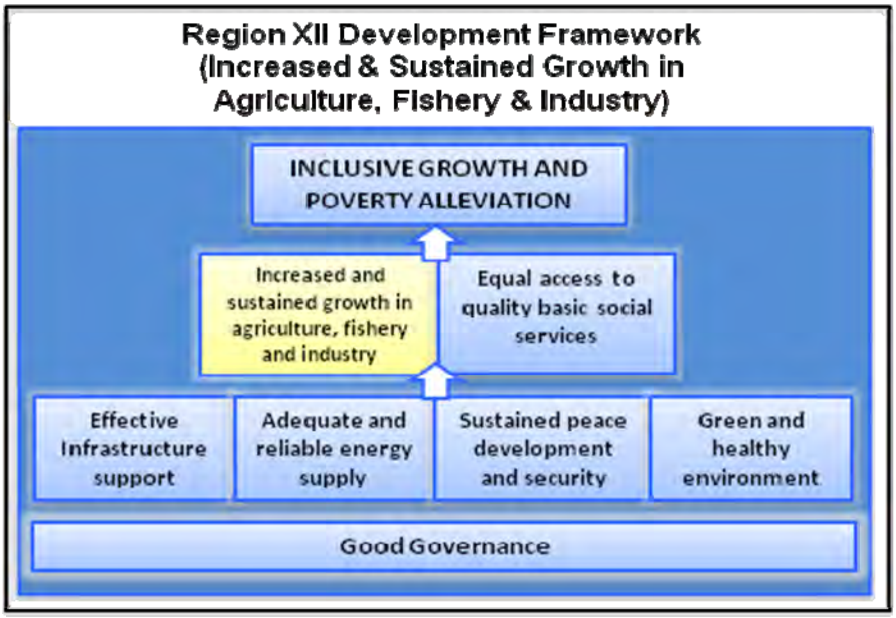
5) Adequate and Reliable Energy Supply
- Energy Independent
- Energy Saving
- Barangay Electrification
- Legislative Agenda

6) Improved Ecological Integrity: Green and Healthy Environment
- Rehabilitation, Conservation and Protection of Ecosystems
- Enforcement and Compliance to Environmental Laws.

7) Sustained Peace, Development and Sea
- Strengthening the Justice System
- Improved Peace and Order
- Improved Public Safety
- Resilient and Progressive Communities in Conflict-affected and Vulnerable Areas

8) Good Governance
- Establishment of the Regional Government Center (RGC)
- Reform in Institution
- Enhancing Local Governance
- Strengthen Private/ Civil Society Participation the Development Process in the “effective Infrastructure Supports”

An effective infrastructure system would enable the integration of local and economic units not only with the major trading and service centers within the region, but also with the other regions in Mindanao and rest of the regions in the country and the world. The region shall continue to pursue the attainment of an effective infrastructure support system that would make possible the achievement of the twin goals of inclusive growth and poverty alleviation.



Source: SOCCSKSARGEN Regional Development Plan 2011-2016

FIGURE 2.4-1 REGION XII DEVELOPMENT FRAMEWORK (EFFECTIVE INFRASTRUCTURE SUPPORT)

CHAPTER 3
ROAD SECTOR OVERVIEW

3.1 DPWH PUBLIC INVESTMENT PROGRAM (2011-2016)

3.1.1 Road Development Goal

The DPWH Public Investment Program (PIP) (2011 - 2016) was formulated by that Department in 2011. Goals were set as follows:

DEVELOPMENT GOALS UNDER DPWH PIP

1. Provide safe environment through quality infrastructure facilities;
2. Increase mobility and total connectivity of people through quality infrastructure resulting to improved quality of life;
3. Strengthen national unity, family bonds and tourism by making the movement of people faster, cheaper and safer;
4. Facilitate the decongestion of Metro Manila via a transport logistics system that would ensure efficient linkages between its business centers and nearby provinces;
5. Implement more Public-Private Partnership (PPP) projects for much needed infrastructure and level playing field for investment;
6. Ensure adequate and sustained maintenance of roads and bridges; and
7. Generate more transport infrastructure with minimal budget requirements and contingent liabilities.

The strategic focus of the DPWH PIP was set as follows;

STRATEGIC FOCUS

- Implement activities in the following order of priorities:
  a. Maintenance or asset preservation – to preserve existing roads in good condition.
  b. Rehabilitation – to restore damaged roads to their original designed condition.
  c. Improvement – to upgrade road features so that they efficiently meet traffic demands.
  d. New Construction
- Prioritize upgrading of the national road network, as to quality and safety standards.
- Prioritize national roads to address traffic congestion and safety in urban centers and designated strategic tourism destinations.
- Complete on-going bridges along national roads.
- Develop more Public-Private Partnership (PPP) projects to accelerate the provision of key infrastructure and level the playing field for investments.
- Study the mechanism for a longer maintenance period (5 – 10 years) for road and bridges under performance-based contracts.
- Prioritize flood control projects in major and principal river basins to address climate change based on master plan and adopt new technologies in flood control and slope management.
- Prioritize adequate flood control and upgraded drainage design standards and facilities in flood-disaster prone areas to mitigate loss of rivers and damage to properties.
- Promote innovative technology such as geo-textiles and coco-netting in slope protection and soil erosion control.
- Promote retarding basin and rain water harvesting for non-domestic use.
- Prioritize water supply in designated strategic tourist destinations/centers.

3.2 DPWH ORGANIZATION

DPWH has recently implemented the Rationalization Plan (RatPlan) pursuant to E.O. No. 366, series of 2004, as per Department Order No. 89, dated September 25, 2013. Important Services and Bureaus have been added and some changes namely: the Bureau of Quality and Safety under the Technical Services; the Public-Private Partnership Service under the Planning and PPP; under the Support Services the Procurement Service and Stakeholders Relations Service were added, Administrative & Manpower Management Service was changed to Human Resource & Administrative Service, Comptrollership & Financial Management Services was changed to Financial and Management Service, and Monitoring & Information Service was changed to Information Management Service; and the PMO Operations become a Unified PMO Operations where it was divided into five (5) different management clusters, namely: Bridges, Flood Control, Roads (Bilateral), Roads (Multilateral) and Buildings. **Table 3.2-1** shows the detailed list of the renaming of some existing services and some of its divisions and divisions in existing bureaus as per Department Order No. 107, series of 2013.

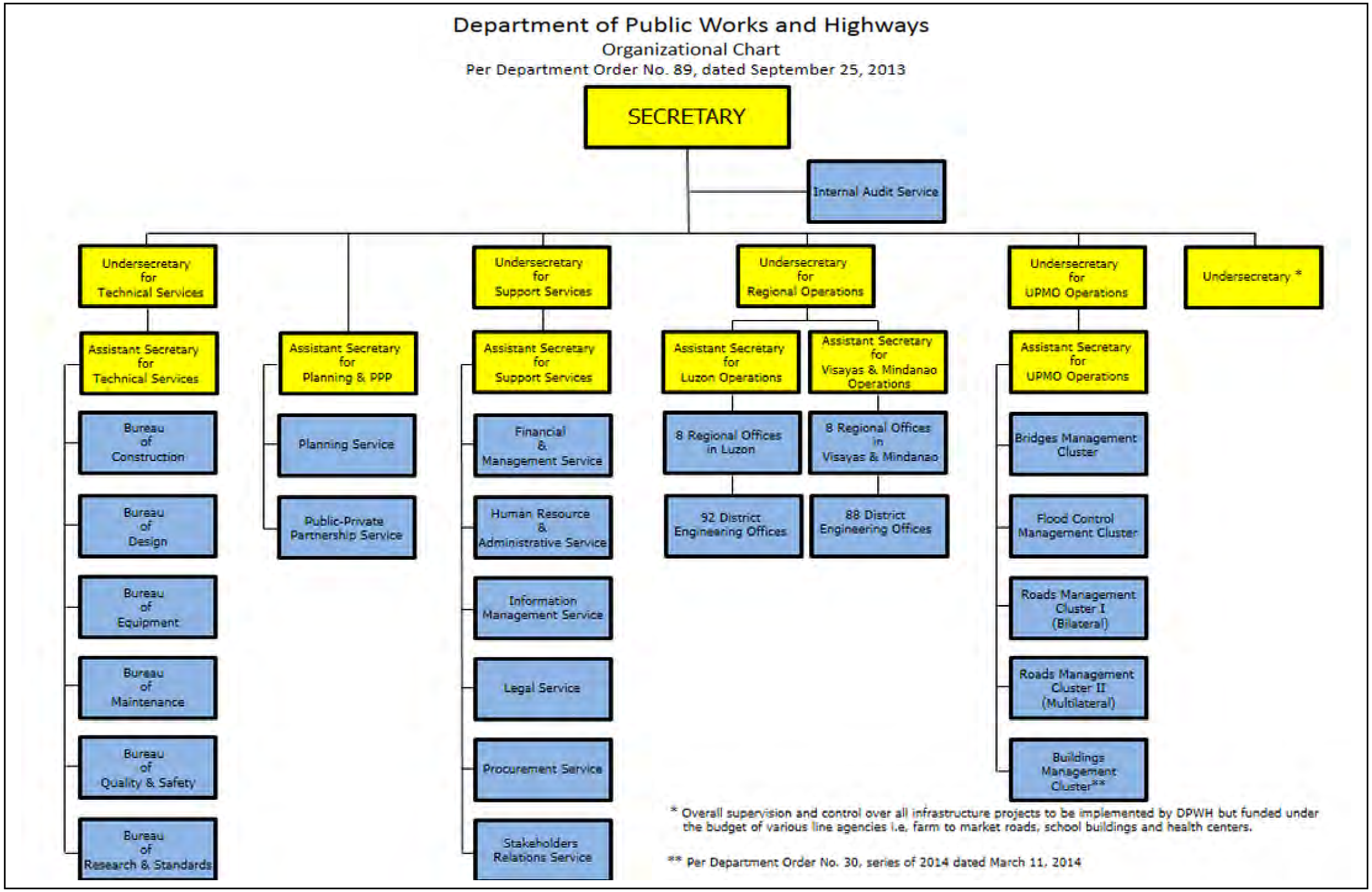
TABLE 3.2-1 LIST OF RENAMING OF SOME EXISTING SERVICES, BUREAUS AND DIVISIONS

Old Name	New Name
SERVICES	
• **Internal Audit Service**	
Financial Audit Division	Financial Operations Audit Division
Operations Audit Division	Technical Operations Audit Division
• **Project Management Office**	**Unified Project Management Office**
PMO for Special Bridges	Bridge Management Office
Flood Control and Sabo Engineering Center	Flood Control Management Office
• **Administrative and Manpower Management Service**	**Human Resource Administrative Service**
Personnel Division	Human Resource Management Division
Human Resource Planning & HR Training & Materials Development Division	Capacity Development Division
• **Comptrollership and Financial Management Service**	**Financial and Management Service**
• **Planning Service**	
Project Evaluation Division	Project Preparation Division
Infrastructure Planning Research & Statistic Division	Statistic Division
• **Legal Service**	
Complaints and Investigation Division	Internal Affairs Division
Site Acquisition and Law Enforcement Division	Right-of-Way Acquisition and Enforcement Division
• **Monitoring and Information Service**	**Information Management Service**
Application Development Division	Application Support Group
BUREAUS	
• **Bureau of Design**	
Hydraulics Division	Water Projects Division
Architectural Division, Structural Division, and Mechanical-Electrical Division	Buildings Division
• **Bureau of Construction**	
Contract Management Division	Claims Review Division
Project Review & Evaluation Division, A, B, C and Pre-Construction Division	Pre-Construction Division

Old Name	New Name
• **<u>Bureau of Maintenance</u>**	
Inspectorate Division	Road Condition Monitoring and Evaluation Division
Monitoring & Methods Division	Policies and Standards Division
Building Services Division	National Building Services Division
• **<u>Bureau of Equipment</u>**	
Equipment Utilization Div. & Equipment Planning Division	Equipment Planning Division
Central Equipment & Spare Parts Division and Equipment Maintenance Division	Equipment Operation and Maintenance Division
• **<u>Bureau of Research & Standards</u>**	
Systems and Standards Division	Standards Development Division
Technical Service and Evaluation Division	Technical Services Division

Source: DPWH Website

Figure 3.2-1 shows the current Organizational Chart of DPWH.



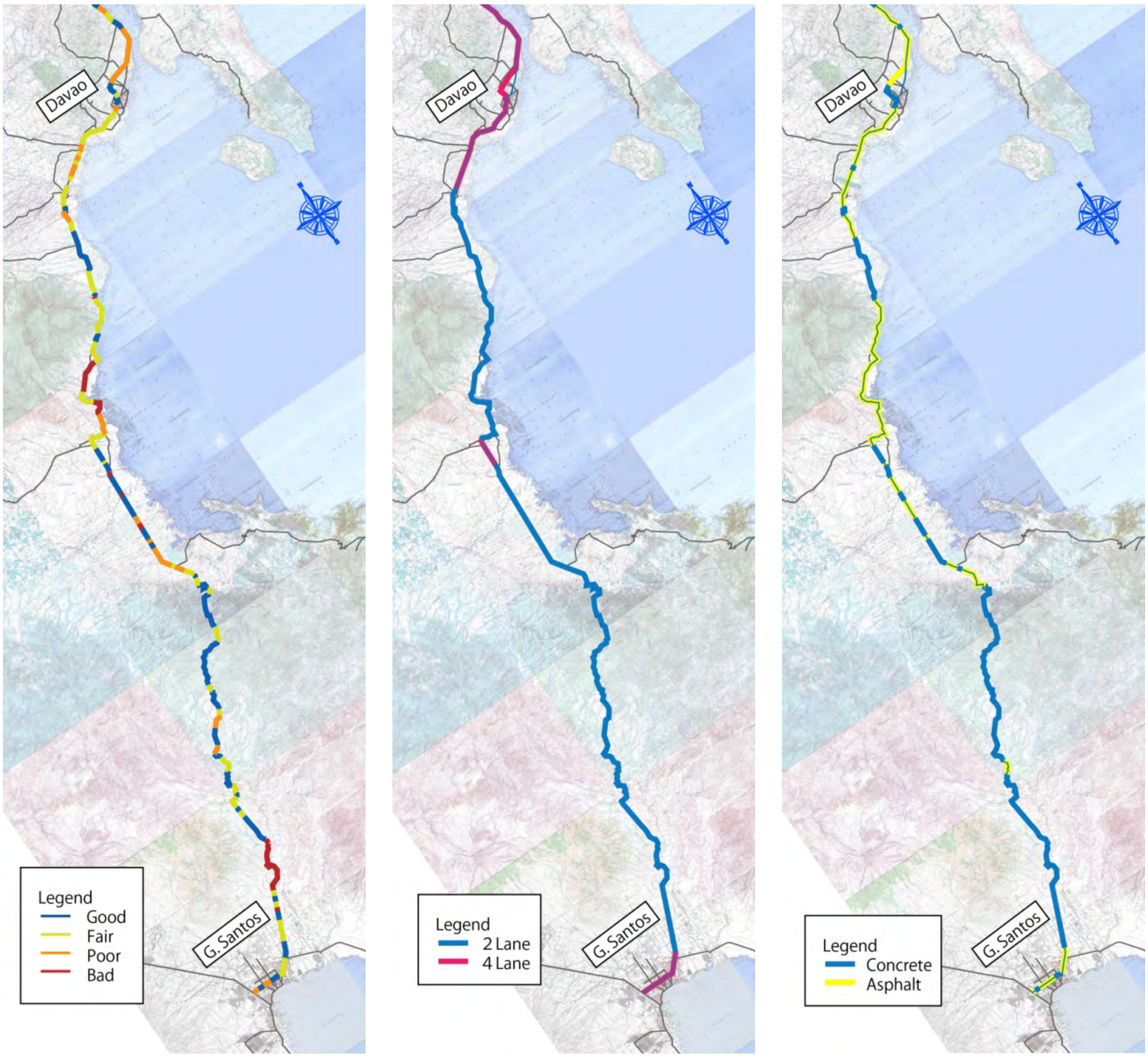
Source: DPWH Website

FIGURE 3.2-1 DPWH ORGANIZATIONAL STRUCTURE

CHAPTER 4
DAVAO CITY – GENERAL SANTOS CITY ROAD IMPROVEMENT PLAN

4.1 PRESENT ROAD CONDITION

JICA Study Team conducted the inventory survey of Davao City – General Santos City Road. **Figure 4.1-1** shows the road condition, the number of lanes and pavement type.



Road Condition | No. of Lane | Pavement Type

Source: JICA Study Team (2013.7)

FIGURE 4.1-1 PRESENT ROAD CONDITION OF DAVAO CITY – GENERAL SANTOS CITY ROAD

For the type of pavement, 103.56km were concrete road and 70.74km were asphalt road, as shown in **Table 4.1-1**.

Most of the road sections are two-lane roads, excluding Davao City, General Santos City and Digos City.

TABLE 4.1-1 PAVEMENT TYPE OF DAVAO CITY – GENERAL SANTOS ROAD

Pavement Type	Length (km)
Concrete	103.56 (59.4%)
Asphalt	70.74 (40.5%)
Gravel	0.12 (0.1%)
Total	**174.42 (100%)**

Source: JICA Study Team

TABLE 4.1-2 PAVEMENT CONDITION BY PAVEMENT TYPE OF DAVAO CITY – GENERAL SANTOS ROAD

Pavement Type / Pavement Condition	Concrete	Asphalt	Gravel	Total
Good	4.67 (4.5%)	20.05 (28.3%)	0 (0%)	24.72 (14.2%)
Fair	8.60 (8.3%)	22.45 (31.7%)	0 (0%)	31.05 (17.8%)
Poor	46.41 (44.8%)	11.34 (16.0%)	0 (0%)	57.75 (33.1%)
Bad	41.15 (39.7%)	11.88 (16.8%)	0 (0%)	53.03 (30.4%)
No Assessment	2.73 (2.6%	5.02 (7.1%)	0.12 (100%)	7.87 (4.5%)
Total	103.56 (100%)	70.74 (100%)	0.12 (100%)	174.42 (100%)

Source: JICA Study Team

Detailed Road Inventory Survey Result is attached in **Appendix 4.1.**

4.2 PRESENT BRIDGE CONDITION

There are twenty seven (27) bridges along the Davao City – General Santos City road stretch with a total bridge length of 1,187.83m. Out of the 27 bridges; only three (3) are in good condition, namely Lasang Bridge, Bunawan Bridge and Padada Bridge. Two (2) bridges however need repairs namely; Coronon Bridge needs repair of pier and Pilan Bridge needs some repair of pavement. Twelve (12) of these bridges are in the Study Area. **Table 4.2-1** shows the result of inventory result of the bridge condition.

TABLE 4.2-1 BRIDGE INVENTORY SURVEY RESULT

No.	District	Road Name	Bridge Name	KM	Position	Number of Lane	Bridge Width (m)	Length (m)	Span	Necessity of Repair	Necessity of Another Bridge Construction	Bridge Type	Condition
1	Davao Del Norte		Lasang Br.	1482+960.50	51 N 794387 804247	4-lane	16.6	60	3	No	No	Concrete	Good
2	Davao City	Daang Mahar	Bunawan Br.	1487+407.00	51 N 791964 800835	4-lane	14.0	43.5	1	No	No	Steel	Good
3	Davao City	Daang Mahar	Ilan Br.	1494+412.12	51 N 793053 794210	4-lane	14.6	18.6	3	No	No	Concrete	Fair
4	Davao City	Daang Mahar	Panacan br.	1497+206.00	51 N 793606 791547	4-lane	16.0	19.4	1	No	No	Concrete	Fair
5	Davao City	Daang Mahar	Sasa br.	1501+501.00	51 N 793201 787497	4-lane	15.4	13.15	1	No	No	Concrete	Fair
6	Davao City	ABS-CBN-Qu	Bolton Br. I	1511+742.80	51 N 787864 780983	4-lane	14.8	185.33	6	No	No	Concrete	Fair
7	Davao City	Davao-Cotaba	Matina Br.	1516+301.69	51 N 783592 781111	4-lane	15.0	26.6	3	No	No	Concrete	Fair
8	Davao City	Davao-City Di	Davao River Br.	1506+764.44	51 N 786567 786232	2-lane	7.4	140.6	4	No	Yes	Concrete	Fair
9	Davao City	Davao-City Di	Pangi Br.	1531+930.50	51 N 783735 781760	2-lane	8.6	100.6	4	No	Yes	Concrete	Fair
10	Davao City	Davao-Cotaba	Talomo Br.-I	1518+406.30	51 N 781623 780948	4-lane	14.8	34.75	1	No	No	Concrete	Fair
11	Davao City	Davao-Cotaba	Bago Br.	1521+009.35	51 N 779590 779332	4-lane	15.0	27.6	3	No	No	Concrete	Fair
12	Davao City	Davao-Cotaba	Lipadas Br.	1528+001.02	51 N 774567 774806	4-lane (Under Construction)	14.8	37.8	3	No	No	Concrete	Fair
13	Davao del Sur	Davao-Cotaba	Inawayan Br.	1532+900.00	51 N 773514 770178	2-lane	7.4	10.4	1	No	Yes	Concrete	Fair
14	Davao del Sur	Davao-Cotaba	Quinokol Br.	1534+900.00	51 N 773156 768432	2-lane	7.2	21	1	No	Yes	Concrete	Fair
15	Davao del Sur	Davao-Cotaba	Cebulan Br.	1536+900.00	51 N 772774 766539	2-lane	7.6	25	1	No	Yes	Steel	Fair
16	Davao del Sur	Davao-Cotaba	Coronon Br. I	1542+950.00	51 N 770937 761005	4-lane (Under Construction)	14.7	24	1	Repair of Pier	No	Concrete	Poor
17	Davao del Sur	Davao-Cotaba	Coronon Br. II	1543+276.75	51 N 770703 760615	2-lane	7.6	36.65	3	No	Yes	Concrete	Fair
18	Davao del Sur	Davao-Cotaba	Pilan Br.	1549+835.00	51 N 766105 756383	2-lane	7.6	21	1	Repair of Pavement	Yes	Concrete	Fair
19	Davao del Sur	Davao-Cotaba	Tagabuli Br.	1555+037.00	51 N 762904 753767	2-lane	7.2	20.6	1	No	Yes	Concrete	Fair
20	Davao del Sur	Davao-Cotaba	Digos Br. - II	1562+458.30	51 N 762345 746705	4-lane	14.8	31.35	1	No	No	Concrete	Fair
21	Davao del Sur	Davao-Cotaba	Balutakay Br.	1568+700.00	51 N 760052 743201	2-lane	7.4	24	1	No	Yes	Concrete	Fair
22	Davao del Sur	Digos-Makar	Padada br.	1571+958.50	51 N 759781 739914	2-lane	7.4	92.5	3	No	Yes	Concrete	Good
23	Sarangani	Digos-Makar	Banate Br.	1601+377.65	51 N 756902 716605	4-lane (Under Construction)	7.6	21.1	1	No	No	Concrete	Fair
24	Sarangani	Digos-Makar	Biangan Br.	1613+489.10	51 N 751960 706711	2-lane	8.4	45.9	3	No	Yes	Concrete	Poor
25	Sarangani	Digos-Makar	Nagpan Br.	1618+418.35	51 N 751325 702869	2-lane	8.2	21.8	1	No	Yes	Concrete	Fair
26	Sarangani	Digos-Makar	Upper Buayan Br.	1623+374.90	51 N 750281 699354	2-lane	7.8	39.6	3	No	Yes	Concrete	Fair
27	South Cotobato	Digos-Makar	Tinagakan Br.	1639+055.00	51 N 747307 686737	2-lane	7.4	45	3	No	Yes	Concrete	Fair

Source: JICA Study Team (2013.7)

CHAPTER 5
SOCIO-ECONOMIC CONDITION OF THE PROJECT AREA: REGION XI AND DAVAO CITY

5.1 STANDING OF DAVAO CITY IN MINDANAO

Davao City has one million four hundred thousand population in year 2010 and it is the largest city in the Mindanao island. In the Philippines, Davao City is the third largest metropolis. As shown in **Figure 5.1-1**, Davao City is the center of Mindanao for commercial, business, financial, industrial and culture. It is also an important city as the center of East ASEAN Growth Region. It has likewise a role of important hub station for land, sea, and air transportation as shown in **Figure 5.1-2**.

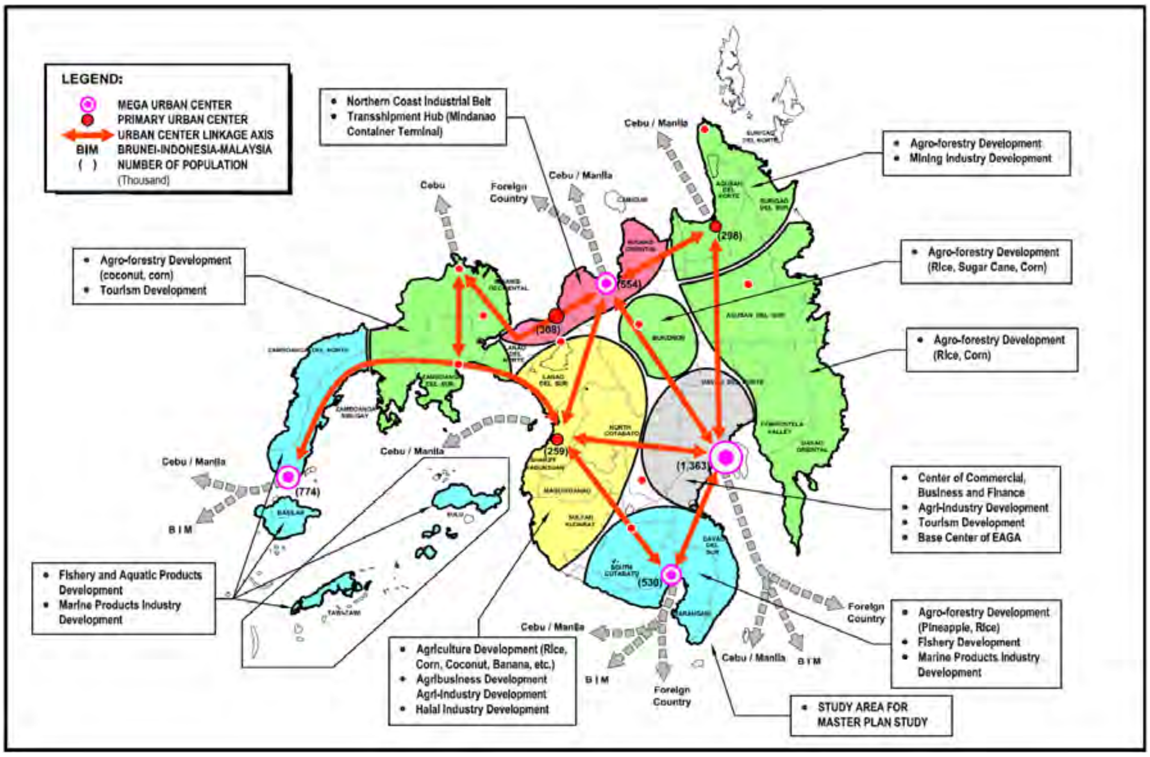


FIGURE 5.1-1 MINDANAO DEVELOPMENT CENTER

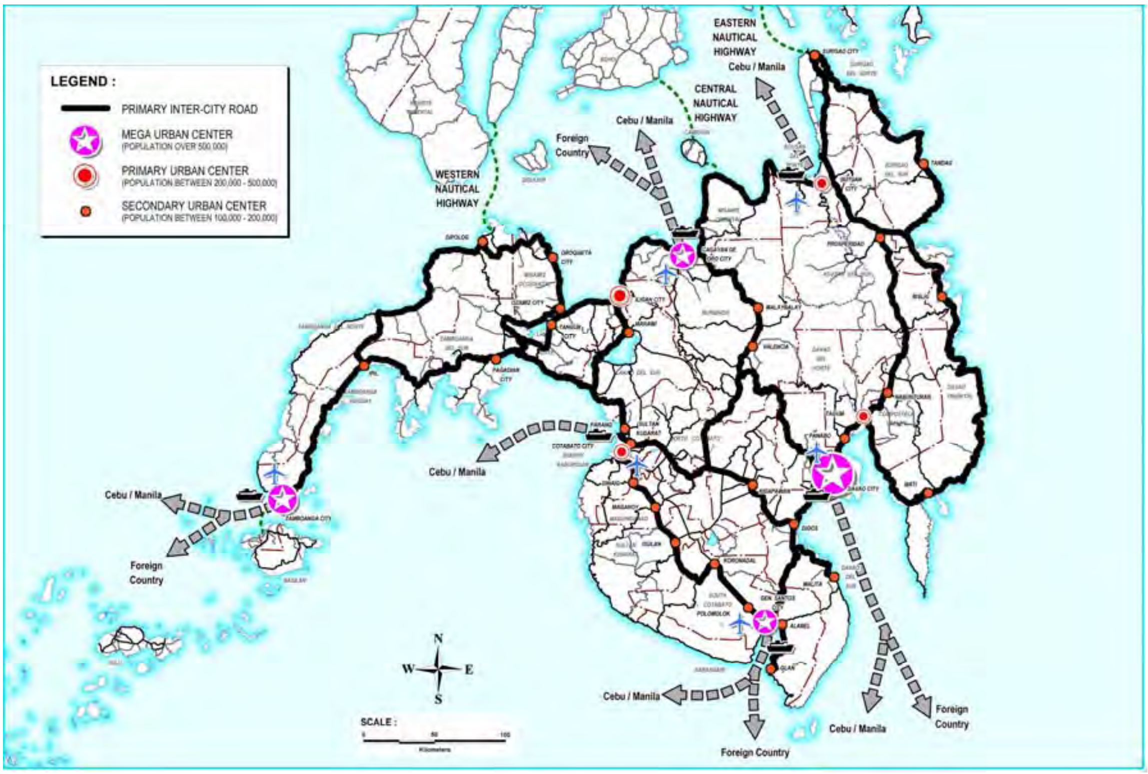


FIGURE 5.1-2 MINDANAO INTER-URBAN TRANSPORT NETWORK

5.2 PHYSICAL PROFILE

The project is located on Region XI specifically in the Davao City and Panabo City. Region XI is composed of four (4) provinces of Compostela Valley, Davao Del Norte, Davao Oriental and Davao Del Sur. The region covers 20,244 sq.km. or 5.8% of country's land area. **Table 5.2-1** shows the land area share of Region XI to country as well as share of neighboring region to the country.

TABLE 5.2-1 LAND AREA SHARE

Region	Land Area (sq.km.)	Share to Philippine	Population (2010)	Density
Philippines	344,879			308/km^2
Region X	20,132	5.8%	4,297,323	210/km^2
Region XI	**20,244**	**5.8%**	**4,468,563**	**260/km^2**
Region XII	22,466	6.5%	4,109,571	180/km^2
Region XIII	21,471	6.2%	2,429,224	110/km^2

5.3 DEMOGRAPHIC TREND

The population of Region XI is 4.47 million in 2010. This number represents 4.8% of the total population of the country. Growth rate in the region is higher than that of national average between 2007-2010 as presented in **Table 5.3-1.**

The population of Davao City is 1.45 million in 2010. As mentioned before, Davao City is the third metropolis in the Philippines and the growth rate of Davao City is much higher than that of the national average. Likewise, the population of Panabo City is 0.17 million in 2010.

Figure 5.3-1 illustrates the population density. High population density of the city center is expanded and the area of coastal side (or along Pan-Philippine Highway) became high density. **Figure 5.3-2** illustrates the population growth rate. Though the growth rate in the city center were low (0-2%), that of inland area were very high (over 5%).

Barangays directly affected by the Davao City Bypass Project are listed in **Table 5.3-2** as illustrated in **Figure 5.3-3.**

TABLE 5.3-1 POPULATION GROWTH RATE

Region/City	District	Actual Population			Land Area	Density (Person /sq km)			Annual Population Growth Rate	
		2000	2007	2010	(sq km)	2000	2007	2010	2000-2007	2007-2010
Philippines		76,504,077	88574614	92,337,852	340,575	225	260	271	2.1%	1.4%
Region XI		3,676,163	4,156,653	4,468,563	20,244	182	205	221	1.8%	2.4%
Davao City	POBLACION	133,639	153,005	156,450	11.5	11,626	13,311	13,611	2.0%	0.7%
	TALOMO	284,100	360,010	382,652	88.1	3,226	4,089	4,346	3.4%	2.1%
	AGDAO	91,397	98,586	99,406	6.1	14,993	16,172	16,307	1.1%	0.3%
	BUHANGIN	193,519	232,865	256,959	96.5	2,005	2,413	2,662	2.7%	3.3%
	BUNAWAN	97,641	123,767	131,704	64.5	1,513	1,918	2,041	3.4%	2.1%
	PAQUIBATO	35,270	38,266	39,698	656.3	54	58	60	1.2%	1.2%
	BAGUIO	24,379	27,255	30,384	188.4	129	145	161	1.6%	3.7%
	CALINAN	67,077	70,840	81,844	229.9	292	308	356	0.8%	4.9%
	MARILOG	42,736	42,718	45,125	631.6	68	68	71	0.0%	1.8%
	TORIL	108,054	126,978	133,452	297.8	363	426	448	2.3%	1.7%
	TUGBOK	69,304	83,863	91,622	149.0	465	563	615	2.8%	3.0%
	TOTAL	**1,147,116**	**1,358,153**	**1,449,296**	**2,419.7**	**474**	**561**	**599**	**2.4%**	**2.2%**

Source: National Statistics Office

TABLE 5.3-2 NUMBERS OF AFFECTED BARANGAYS BY DISTRICT

City	District	Barangay Name	# of Affected Barangays
Davao City	1st	Catalunan Grande	3
		Magtuod	
		Langub	
	2nd	Waan	10
		Tigatto	
		Cabantian	
		Communal	
		Indangan	
		Mudiang	
		Tibungco	
		Mahayag	
		San Isidro	
		Lasang	
	3rd	Sirawan	12
		Marapangi	
		Bato	
		Lubogan	
		Alambre	
		Bangkas Heights	
		Mulig	
		Bago Oshiro	
		Mintal	
		Tugbok Proper	
		Tacunan	
		Matina Biao	
Panabo City		J.P. Laurel	1

Source: City Planning and Development Offices

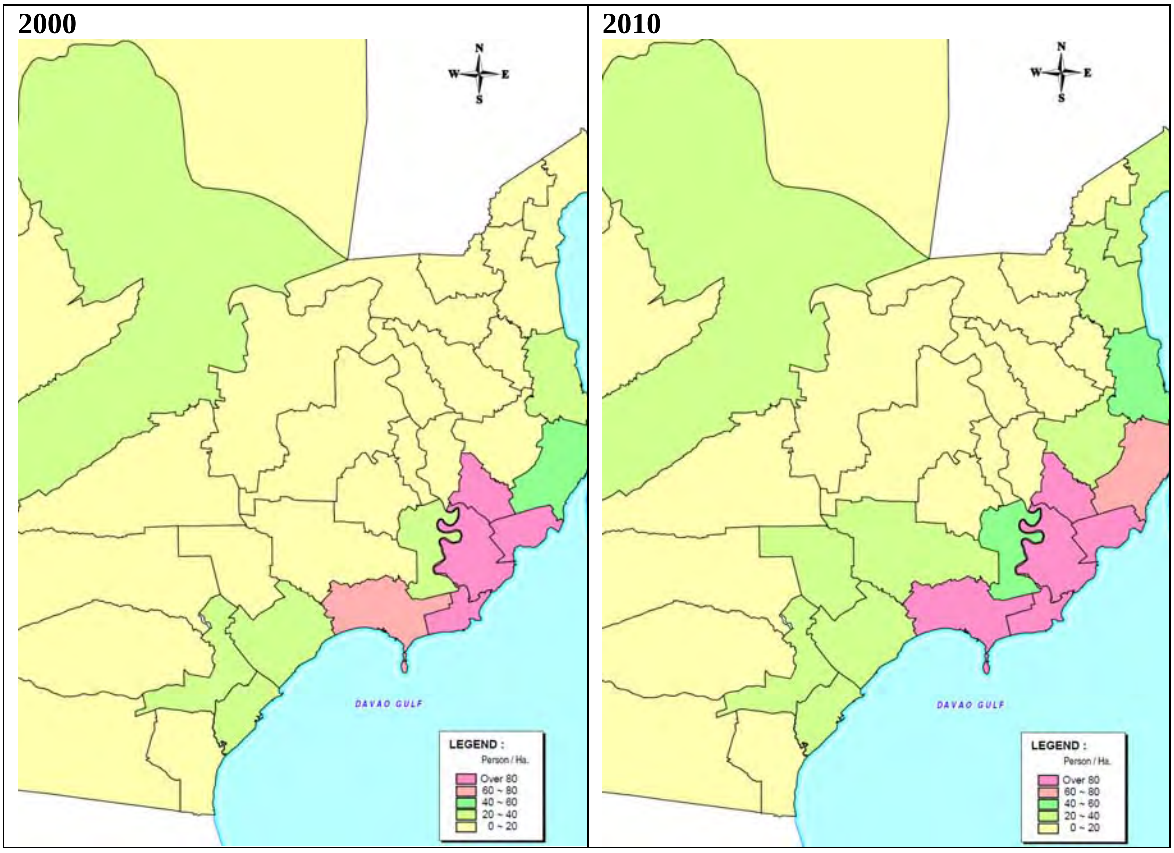


FIGURE 5.3-1 POPULATION DENSITY

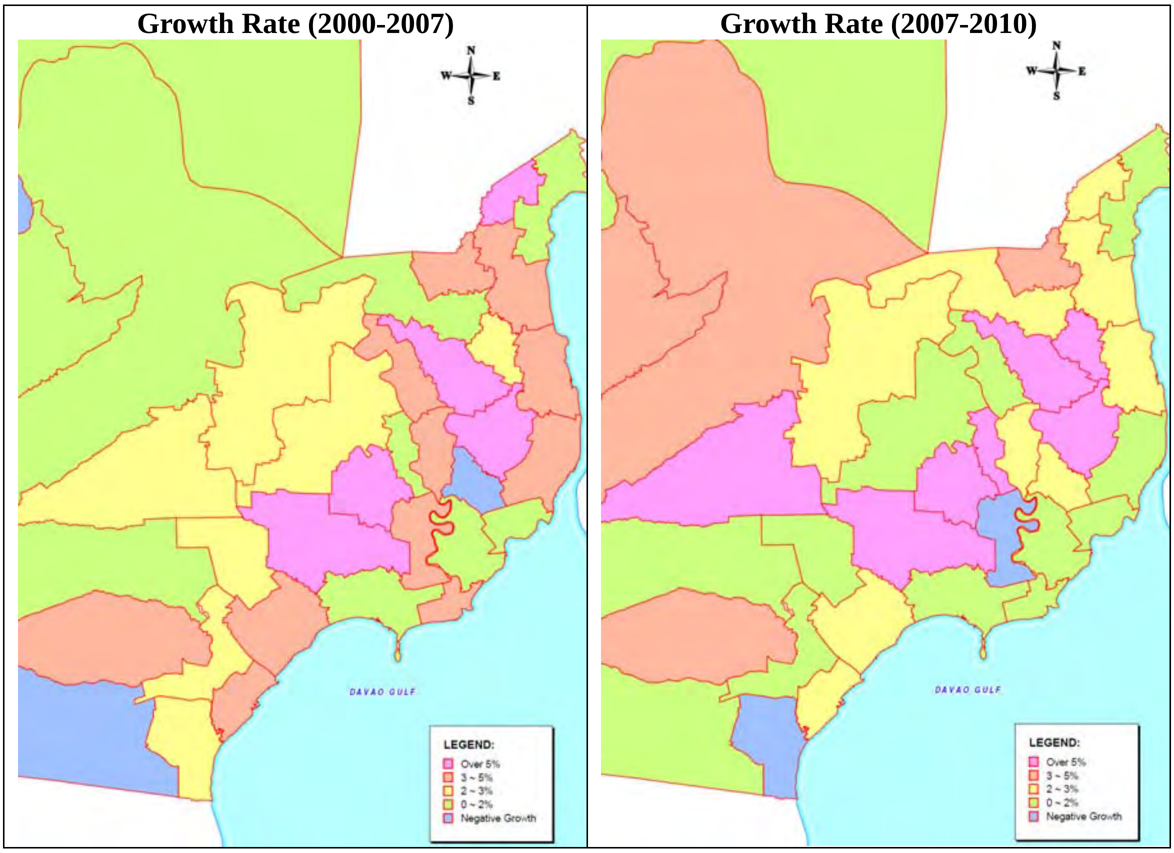
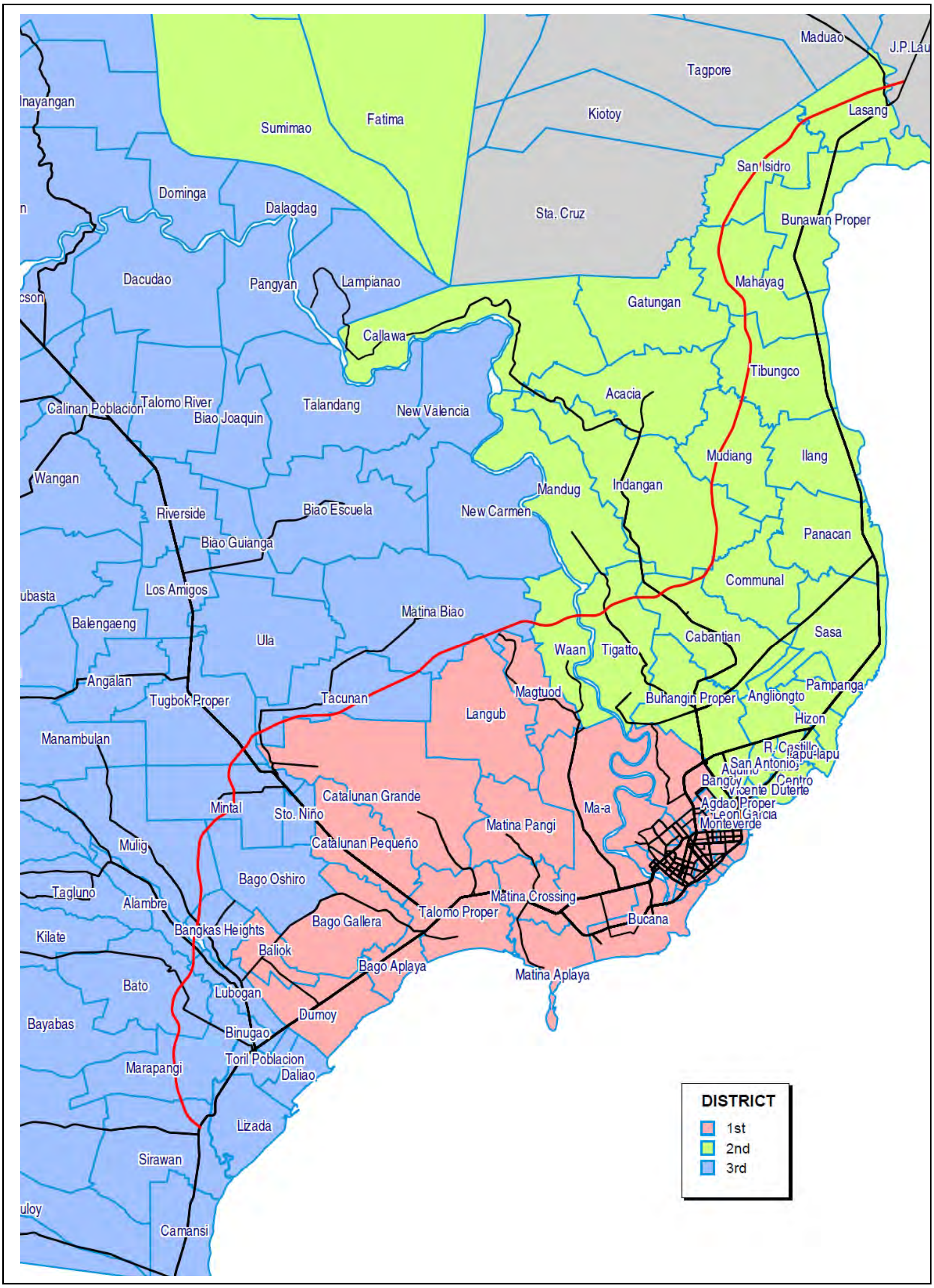


FIGURE 5.3-2 POPULATION GROWTH RATE



Source: Davao City Planning and Development Office

FIGURE 5.3-3 DISTRICT MAP OF DAVAO CITY

5.4 ECONOMIC TREND

The GRDP of Region XI as well as neighboring regions is shown in **Table 5.4-1.** The highest share of GRDP in Mindanao was 27% in Region XI. Region XI (Davao City) and Region X (Cagayan de Oro City and etc.) are the main key players for Mindanao' economic growth.

Growth rate of Region XI was lower than that of Mindanao, but it was higher than the national growth rate.

TABLE 5.4-1 GDP AND GRDP IN CONSTANT PRICE

Item	GRDP in Constant Price (thousand Php)			Share in Mindanao (2012)	Growth Rate	
	2010	2011	2012		2010-2011	2011-2012
Philippines	5,701,539,196	5,908,999,733	6,311,670,842		3.64%	6.81%
NCR	2,038,178,776	2,101,687,899	2,255,116,040		3.12%	7.30%
Region IX	117,018,919	117,182,723	131,695,644	14%	0.14%	12.38%
Region X	210,965,521	223,160,739	239,677,173	26%	5.78%	7.40%
Region XI	***217,313,462***	***225,455,325***	***242,230,400***	***27%***	***3.75%***	***7.44%***
Region XII	151,318,180	159,309,865	172,262,219	19%	5.28%	8.13%
Region XIII	64,534,772	70,002,372	77,426,887	8%	8.47%	10.61%
ARMM	47,610,858	47,478,614	48,038,871	5%	-0.28%	1.18%

Source: NSCB website 2013

The industrial structures of the economy of Region XIare as follows: Primary sector (23%), Secondary sector (26%) and Tertiary sector (51%) as shown in **Table 5.4-2.**

The share of Tertiary sector of Region XI was higher than that of other regions in Mindanao.

TABLE 5.4-2 INDUSTRIAL STRUCTURE OF THE ECONOMY 2013

At Current Prices **Unit: in Million Pesos**

	Primary	Secondary	Tertiary	Total
Philippines	1,250,616	3,284,508	6,029,762	10,564,886
NCR	9,945	649,018	3,171,872	3,830,834
Region IX	56,741	66,747	93,122	216,610
Region X	110,879	127,461	171,258	409,598
Region XI	97,974	109,121	216,624	423,719
Region XII	113,473	82,208	104,008	299,689
Region XIII	28,328	34,978	59,156	122,462
ARMM	60,907	4,385	28,022	93,314
Mindanao	468,301	424,899	672,190	1,565,390
In percentage				
Philippines	11.8%	31.1%	57.1%	100%
NCR	0.3%	16.9%	82.8%	100%
Region IX	26.2%	30.8%	43.0%	100%
Region X	27.1%	31.1%	41.8%	100%
Region XI	**23.1%**	**25.8%**	**51.1%**	**100%**
Region XII	37.9%	27.4%	34.7%	100%
Region XIII	23.1%	28.6%	48.3%	100%
ARMM	65.3%	4.7%	30.0%	100%

Source: NSCB 2013

5.5 PER CAPITA GDP AND GRDP

The per capita GRDP in current price and constant price are shown in **Table 5.5-1** and **Table 5.5-2** respectively. Though GRDP of Region XI was higher than that of other regions in Mindanao, it was a bit lower than national average.

The country's per capita GDP grew by 4.2% per year from 2009 to 2012. Region XI's growth rate was 3.8%.

TABLE 5.5-1 PER CAPITA IN CURRENT PRICE

unit: Peso

	2009	2010	2011	2012	
Philippines	88,180	97,227	103,056	110,314	1.00
NCR	245,500	271,255	286,458	312,137	2.83
Region IX	50,731	53,822	56,863	61,324	0.56
Region X	71,424	79,901	86,447	91,654	0.83
Region XI	**76,435**	**83,721**	**89,156**	**91,312**	**0.83**
Region XII	54,155	60,204	64,782	69,663	0.63
Region XIII	36,318	40,345	43,935	48,954	0.44

Source: NSCB website 2013

TABLE 5.5-2 PER CAPITA IN CONSTANT PRICE OF YEAR 2000

unit: Peso

	2009	2010	2011	2012	Growth Rate
Philippines	58,199	61,570	62,739	65,904	4.2%
NCR	162,321	171,442	173,975	183,747	4.2%
Region IX	34,353	34,245	33,726	37,284	2.8%
Region X	46,818	48,940	50,838	53,632	4.6%
Region XI	**46,721**	**48,487**	**49,431**	**52,201**	3.8%
Region XII	36,688	36,688	37,813	40,043	3.0%
Region XIII	24,264	26,504	28,362	30,951	8.5%

Source: NSCB website 2013

5.6 EMPLOYMENT

The number of establishments in Davao City reaches 34,566 in 2011. This said number of establishment generated 216,648 employees in Davao City.

The share of establishment and employees of Poblacion in 2011 is high at 38% and 42%, respectively.

TABLE 5.6-1 NUMBER OF ESTABLISHMENTS AND EMPLOYMENTS IN DAVAO CITY

District	No. of Establishments		No. of Employees		Growth Rate	
	2010	2011	2010	2011	No. of Establishments	No. of Employees
Poblacion	11,711	12,321	74,262	91,666	5.2%	23.4%
Talomo	7,696	8,099	32,722	44,755	5.2%	36.8%
Agdao	2,765	2,906	12,673	13,237	5.1%	4.5%
Buhangin	5,257	5,568	34,084	33,783	5.9%	-0.9%
Bunawan	1,225	1,312	11,435	11,541	7.1%	0.9%
Paquibato	77	91	57	60	18.2%	5.3%
Baguio	181	175	1,742	1,764	-3.3%	1.3%
Calinan	1,081	1,183	4,212	4,969	9.4%	18.0%
Marilog	147	161	199	1,864	9.5%	836.7%
Toril	1,718	1,779	9,545	9,873	3.6%	3.4%
Tugbok	833	921	2,994	3,106	10.6%	3.7%
No barangay		50		30	-	-

Source: NSO, Statistical Sampling and Operation Division, List of Establishments

5.7 PRESENT AND FUTURE LAND USE PLAN OF DAVAO CITY

Figure 5.7-1 shows the Present Land Use. The proposed alignment is avoiding the residential, industrial and institutional areas.

Figure 5.7-2 shows the Land Use Plan, the proposed alignment is passing through planned industrial zone (I-1, I-2 and I-3), medium density residential zone (R-2) and agricultural and pasture land zone. There is conservation area near the alignment.

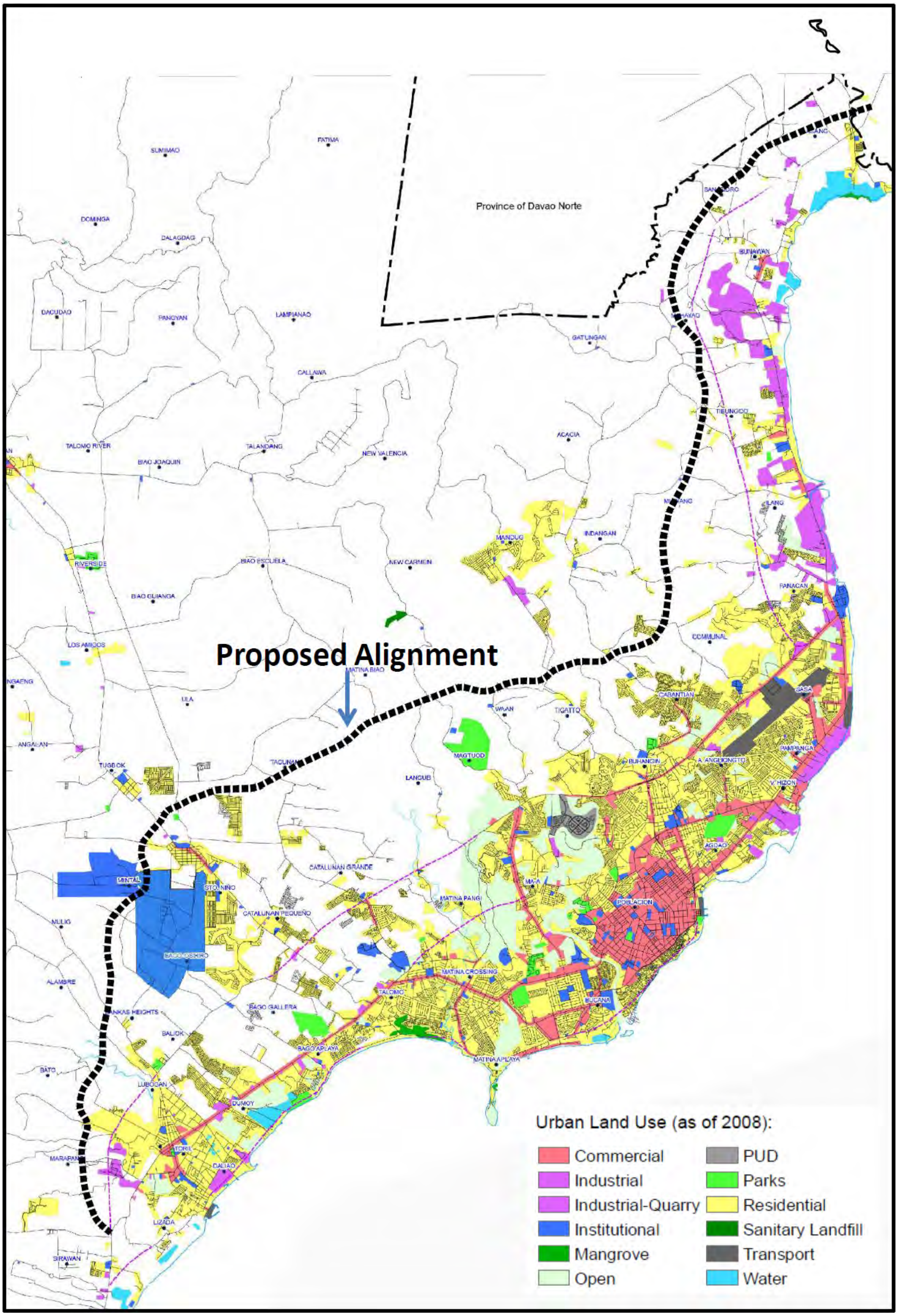


FIGURE 5.7-1 PRESENT LAND USE IN DAVAO CITY (AS OF 2008)

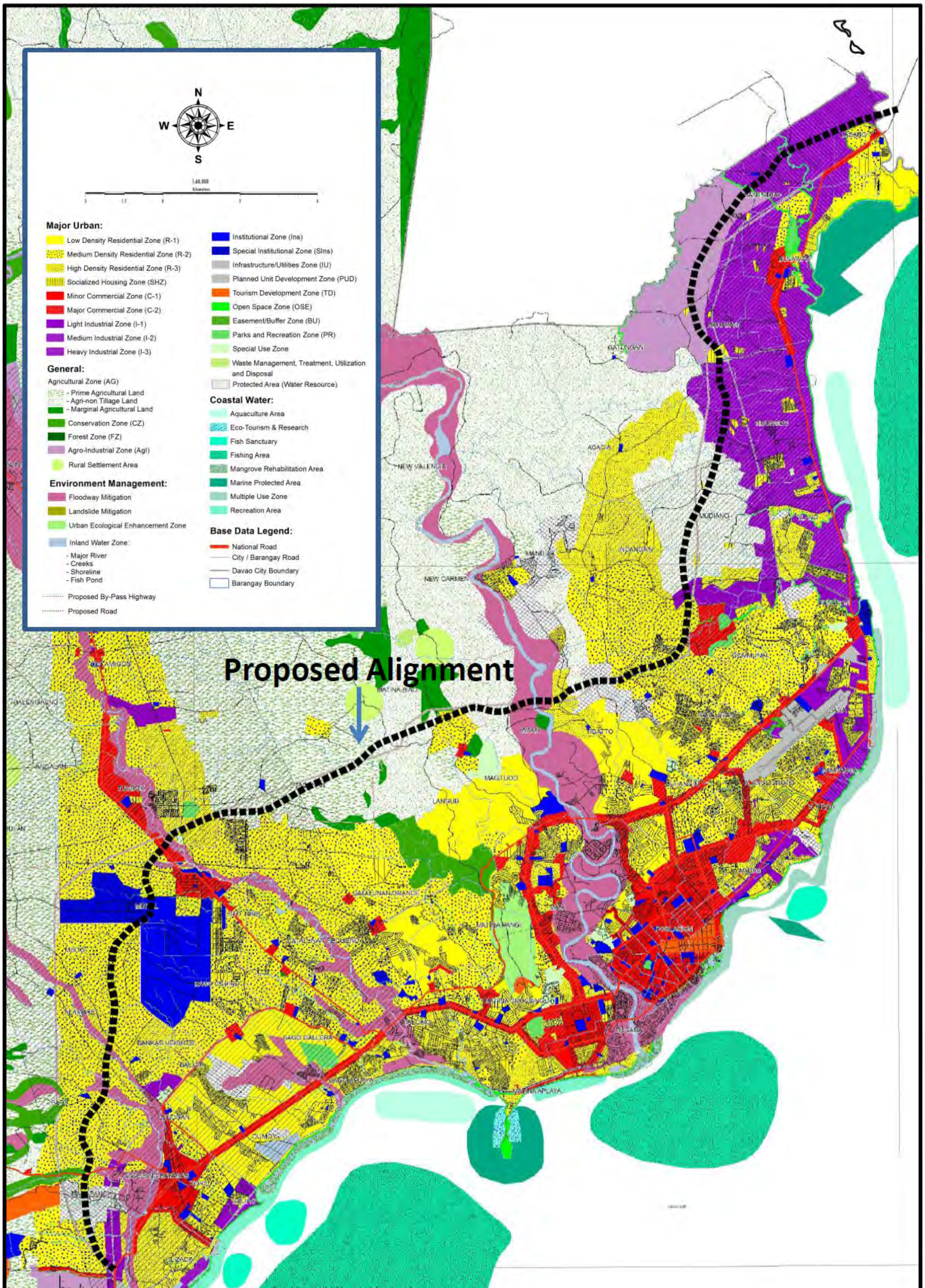


FIGURE 5.7-2 LAND USE PLAN IN DAVAO CITY

CHAPTER 6
TRAFFIC STUDY

6.1 PRESENT TRAFFIC CONDITION

Several traffic of surveys was carried out to better understand the characteristics of the survey area as shown in **Table 6.1.1-1**. Aside from the traffic survey, focus was also given to logistics movement to determine which roads are heavily used by trucks and which port/airport serve as gateway to the manufacturing companies in Davao City. All survey forms are available in **Appendix 6-1**. Detail discussions of each type of survey are presented in the succeeding sections.

6.1.1 Type of Surveys Carried Out

There were six (6) kinds of traffic surveys that were carried out to better understand the characteristics of the survey area. (see **Table 6.1-1**).

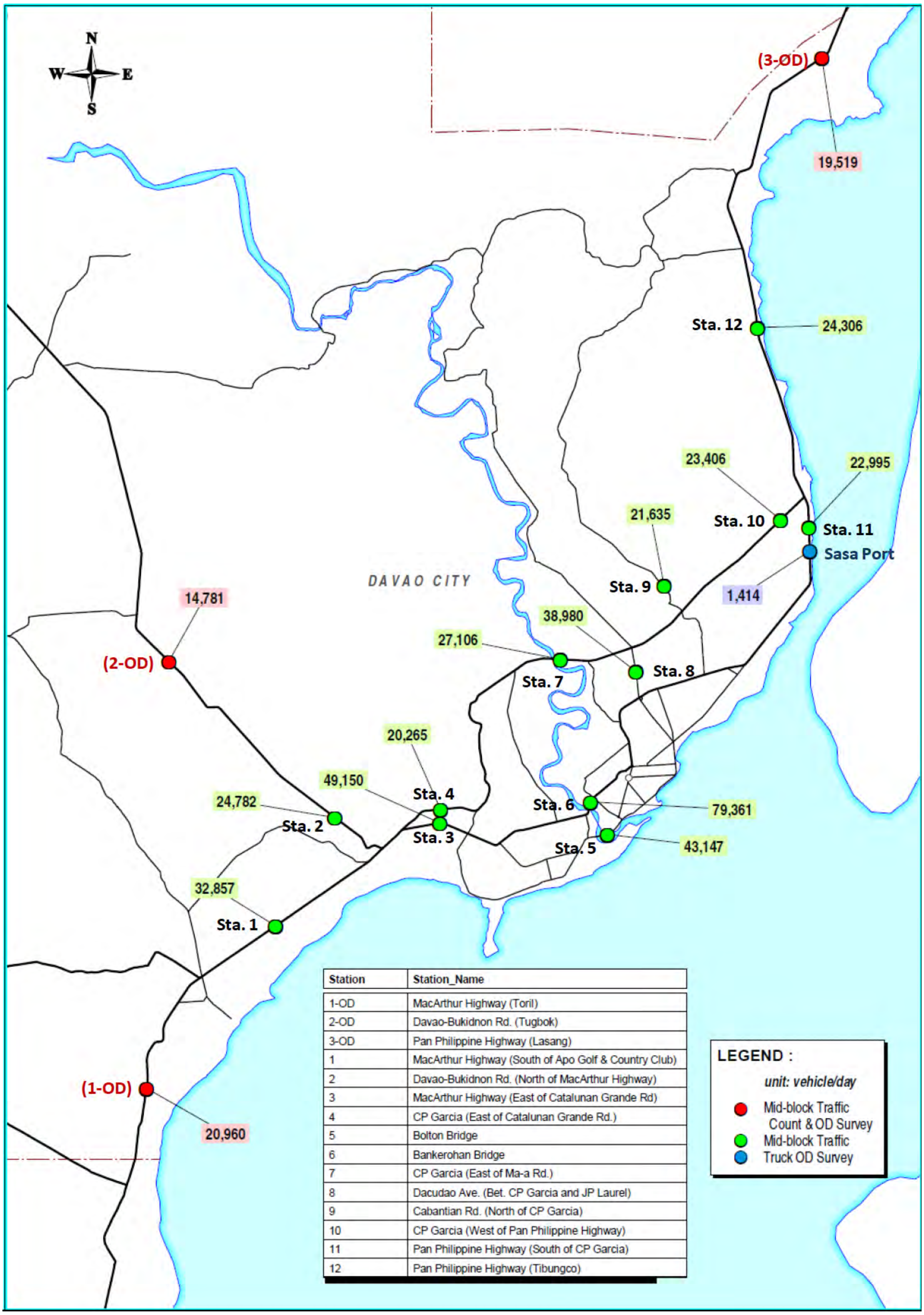
TABLE 6.1-1 TYPE OF SURVEYS CARRIED OUT

Survey Type	Number of Stations/Samples
(1) 24 hour Traffic Count Survey	12
(2) Roadside OD Survey	3
(3) Truck OD and Traffic Count Survey at Sasa Port	1
(4) Interview Survey at Ports/Airports	3/1
(5) Japanese Company Interview Survey	10
(6) Travel Time Survey	3

6.1.2 Traffic Volume

Traffic Volume Count Survey was carried out to count and classify motor vehicles traversing a particular road section and recording the data to determine the present traffic volume and traffic composition. The 24-hour traffic counts were undertaken in the busy city corridors of Davao City.

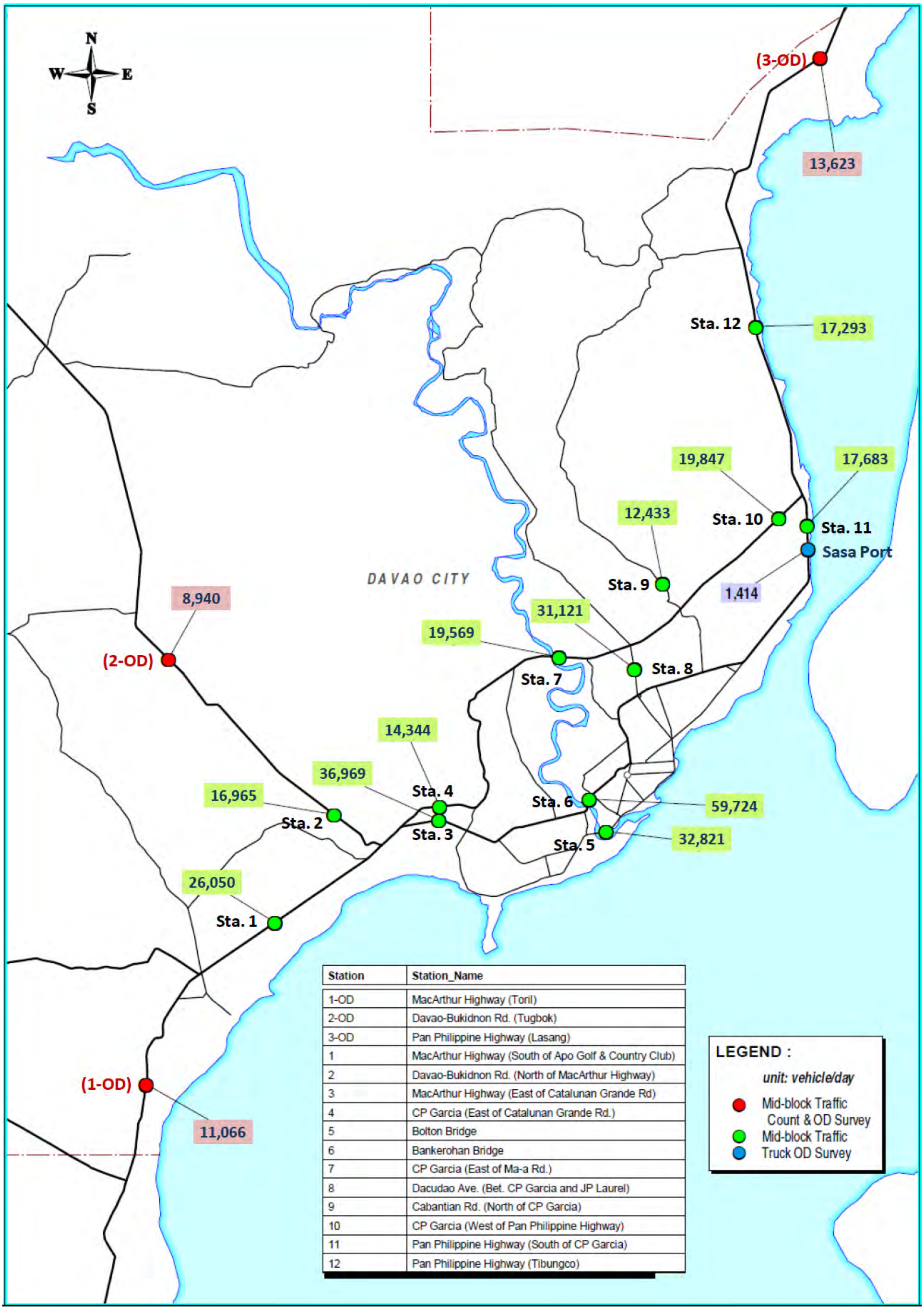
Figure 6.1-1 and **Figure 6.1-2** illustrates the 24-hour traffic count result. The highest volume was 79,361 veh./day (or 59,724 veh/day excluding tricycle and motorcycle) at Bankerohan Bridge along Mc. Arthur Highway. The traffic volume along Diversion Road was from 20,265 ~ 27,106 veh/day (or 14,344 ~ 19,569 veh/day excluding tricycle/motorcycle). The traffic volume along Mc Arthur Highway at the south section was 20,960 ~ 32,857 veh/day (or 11,066 ~ 26,050 veh/day excluding tricycle/motorcycle). While the traffic volume along Mc Arthur Highway at the north section was 19,519 ~ 24,306 (or 13,623 ~ 17,293 veh/day excluding tricycle/motorcycle). It was quite notable that volume of tricycles/motorcycles composed about 35~ 50% of the entire traffic volume. Furthermore, volume of tracks at the Sasa Port was 1,414 vehicle/16 hour.



Station	Station_Name
1-OD	MacArthur Highway (Toril)
2-OD	Davao-Bukidnon Rd. (Tugbok)
3-OD	Pan Philippine Highway (Lasang)
1	MacArthur Highway (South of Apo Golf & Country Club)
2	Davao-Bukidnon Rd. (North of MacArthur Highway)
3	MacArthur Highway (East of Catalunan Grande Rd)
4	CP Garcia (East of Catalunan Grande Rd.)
5	Bolton Bridge
6	Bankerohan Bridge
7	CP Garcia (East of Ma-a Rd.)
8	Dacudao Ave. (Bet. CP Garcia and JP Laurel)
9	Cabantian Rd. (North of CP Garcia)
10	CP Garcia (West of Pan Philippine Highway)
11	Pan Philippine Highway (South of CP Garcia)
12	Pan Philippine Highway (Tibungco)

Source: JICA Study Team

FIGURE 6.1-1 24-HOUR TRAFFIC COUNT SURVEY RESULT (INCLUDING TRICYCLE/MOTORCYCLE)



Station	Station_Name
1-OD	MacArthur Highway (Toril)
2-OD	Davao-Bukidnon Rd. (Tugbok)
3-OD	Pan Philippine Highway (Lasang)
1	MacArthur Highway (South of Apo Golf & Country Club)
2	Davao-Bukidnon Rd. (North of MacArthur Highway)
3	MacArthur Highway (East of Catalunan Grande Rd)
4	CP Garcia (East of Catalunan Grande Rd.)
5	Bolton Bridge
6	Bankerohan Bridge
7	CP Garcia (East of Ma-a Rd.)
8	Dacudao Ave. (Bet. CP Garcia and JP Laurel)
9	Cabantian Rd. (North of CP Garcia)
10	CP Garcia (West of Pan Philippine Highway)
11	Pan Philippine Highway (South of CP Garcia)
12	Pan Philippine Highway (Tibungco)

Source: JICA Study Team

FIGURE 6.1-2 24-HOUR TRAFFIC COUNT SURVEY RESULT (EXCLUDING TRICYCLE/MOTORCYCLE)

6.1.3 Hourly Traffic Variation

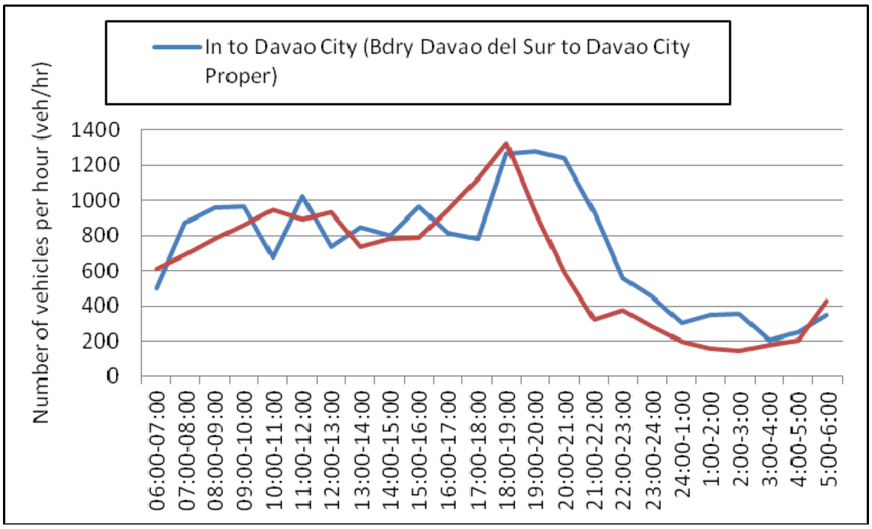
Major points were summarized below.

- The peak time of "In to Davao City" is from 7:00 – 8:00 in the morning. Peak rate is very high at 9.8% in Station 3, Mc Arthur Highway.
- The peak time of "Out from Davao City" is at 17:00. This evening peak rate is lower than the morning peak of "In to Davao City"

The following were the observed hourly traffic variation in the following stations:

Station 1: Mc Arthur Highway (South of Apo Golf and Country Club)

- The highest number of passing vehicles was recorded between 18:00 to 19:00 with 1,330 veh/hr and the direction was going out from the city, from the Davao City Proper going out to the Bdry. of Davao del Sur.
- Peak time for vehicles going in to the city was from 18:00 to 21:00 while peak time for vehicles going out of the city was from 17:00 to 19:00.

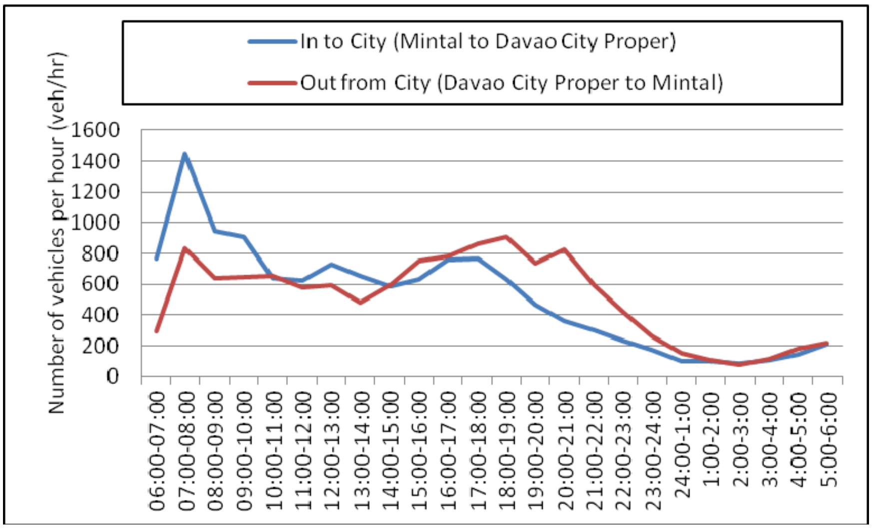


Source: JICA Study Team

FIGURE 6.1-3 HOURLY TRAFFIC VARIATION AT MAC ARTHUR HIGHWAY (MC ARTHUR HIGHWAY SECTION)

Station 2: Davao – Bukidnon Road (North of Mc Arthur Highway)

- The highest number of passing vehicles was recorded between 7:00 to 8:00 with 1,447 veh/hr and the direction was going in to the Davao City Proper coming from Mintal.
- Peak time for vehicles going in to the city was from 7:00 to 8:00 while peak time for vehicles going out of the city is at 17:00 to 18:00.

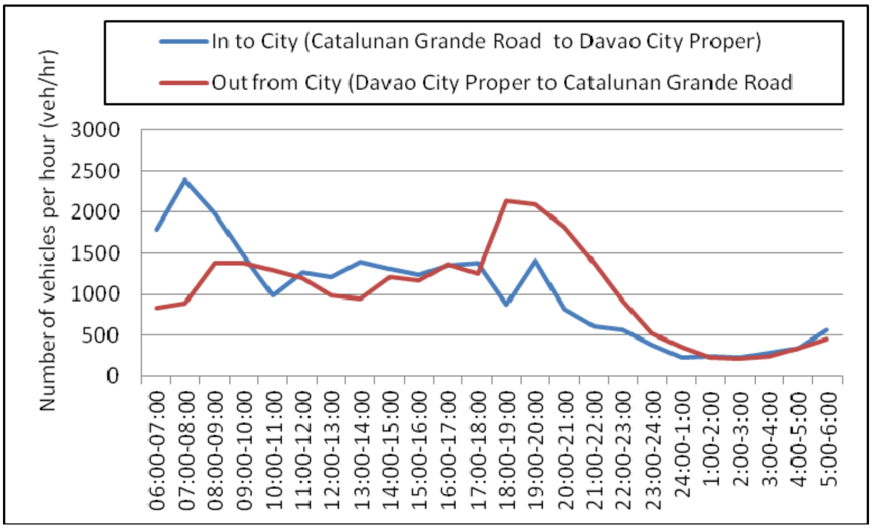


Source: JICA Study Team

FIGURE 6.1-4 HOURLY TRAFFIC VARIATION AT DAVAO – BUKIDNON ROAD (NORTH OF MC ARTHUR HIGHWAY)

Station 3: Mc Arthur Highway (East of Catalunan Grande Road)

- The highest number of passing vehicles was recorded between 7:00 to 8:00 with 2,389 veh/hr and the direction was going in to the Davao City Proper coming from East of Catalunan Grande Road.
- Peak time for vehicles going in to the city was from 7:00 to 8:00 while peak time for vehicles going out of the city is at 18:00 to 20:00.

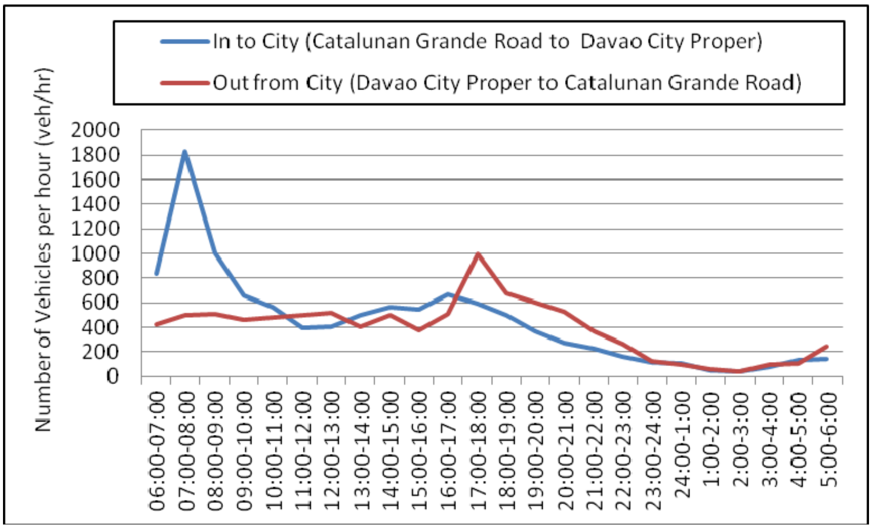


Source: JICA Study Team

FIGURE 6.1-5 HOURLY TRAFFIC VARIATION AT MC ARTHUR HIGHWAY (EAST OF CATALUNAN GRANDE ROAD)

Station 4: CP Garcia (East of Catalunan Grande Road)

- The highest number of passing vehicles was recorded between 7:00 to 8:00 with 1,830 veh/hr and the direction was going in to the Davao City Proper coming from CP Garcia (East of Catalunan Grande Road).
- Peak time for vehicles going in to the city was from 7:00 to 8:00 while peak time for vehicles going out of the city is at 17:00 to 18:00.

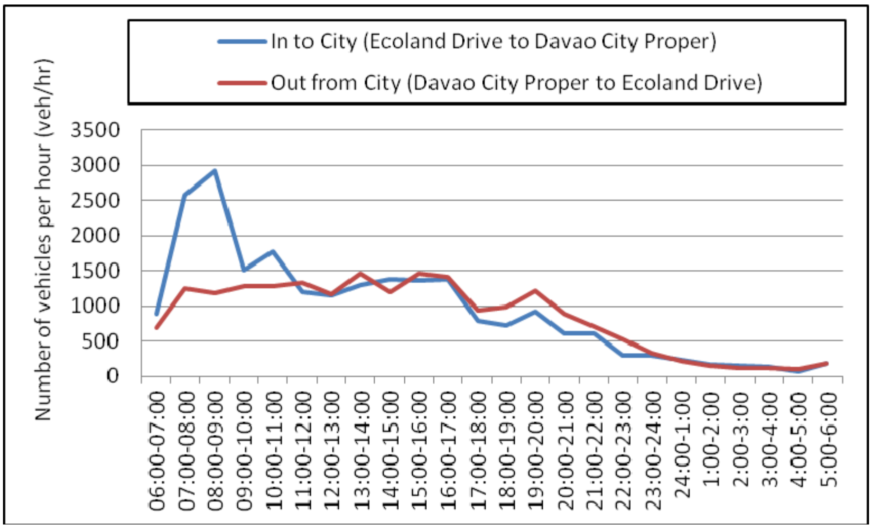


Source: JICA Study Team

FIGURE 6.1-6 HOURLY TRAFFIC VARIATION AT CP GARCIA (EAST OF CATALUNAN GRANDE ROAD)

Station 5: Bolton Bridge

- The highest number of passing vehicles was recorded between 8:00 to 9:00 with 2,916 veh/hr and the direction was going in to the Davao City Proper passing through the Bolton Bridge.
- Peak time for vehicles going in to the city was from 7:00 to 9:00 while vehicles going out of the city varied just at a range 1,000 to 1,500 veh/hr from 7:00 to 17:00.

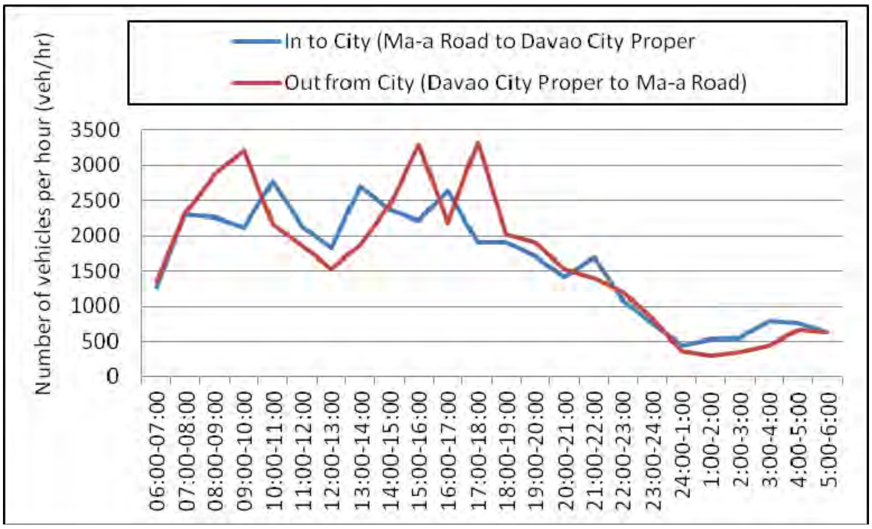


Source: JICA Study Team

FIGURE 6.1-7 HOURLY TRAFFIC VARIATION AT BOLTON BRIDGE

Station 6: Bankerohan Bridge

- The highest number of passing vehicles was recorded between 17:00 to 18:00 with 3,328 veh/hr and the direction was going out from Davao City Proper passing through the Bankerohan Bridge.
- Vehicular traffic at Bankerohan Bridge was almost all-the-time heavy from 6:00 to 23:00 ranging only from more than 1,000 to less than 3,500 veh/hr.

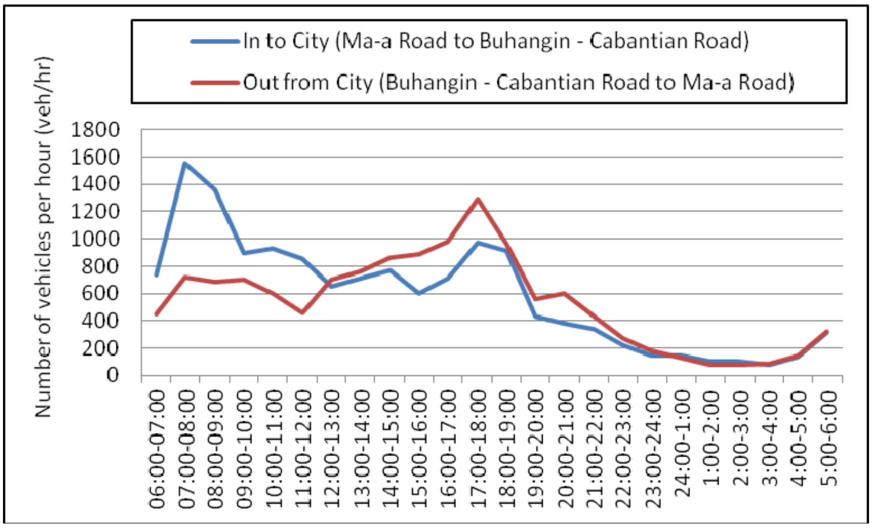


Source: JICA Study Team

FIGURE 6.1-8 HOURLY TRAFFIC VARIATION AT BANKEROHAN BRIDGE

Station 7: CP Garcia (East of Ma-a Road)

- The highest number of passing vehicles was recorded between 7:00 to 8:00 with 1,550 veh/hr and the direction was going in to the Davao City Proper.
- Peak time for vehicles going in to the city was from 7:00 to 9:00 while for going out of the city was from 17:00 to 18:00.

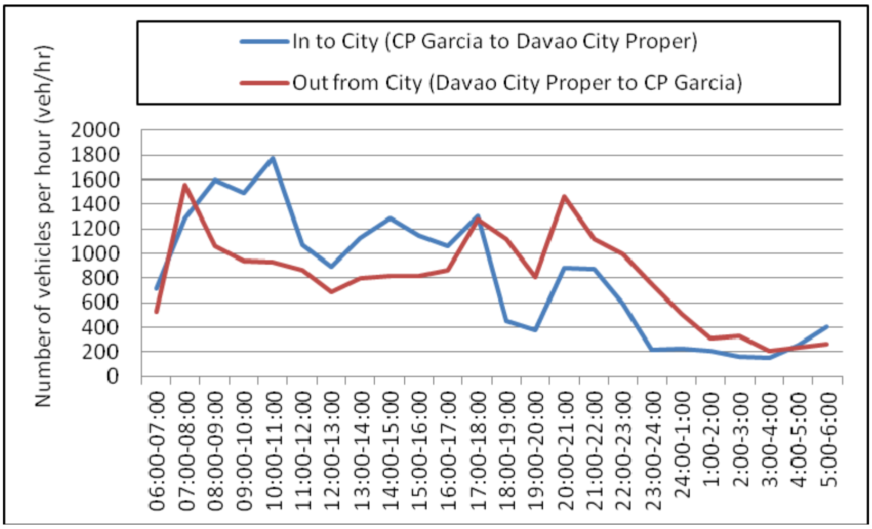


Source: JICA Study Team

FIGURE 6.1-9 HOURLY TRAFFIC VARIATION AT CP GARCIA (EAST OF MA-A ROAD)

Station 8: Dacudao Avenue (between CP Garcia and JP Laurel)

- The highest number of passing vehicles was recorded between 10:00 to 11:00 with 1,770 veh/hr and the direction was going in to the Davao City Proper.
- Peak time for vehicles going in to the city was from 8:00 to 11:00 while for going out of the city was from 7:00 to 8:00.

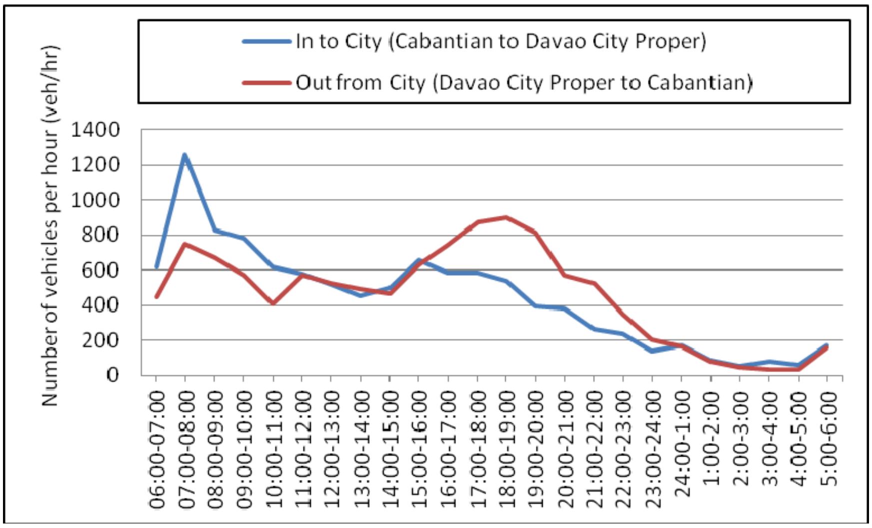


Source: JICA Study Team

FIGURE 6.1-10 HOURLY TRAFFIC VARIATION AT DACUDAO AVENUE (BETWEEN CP GARCIA AND JP LAUREL)

Station 9: Cabantian Road (North of CP Garcia)

- The highest number of passing vehicles was recorded between 7:00 to 8:00 with 1,259 veh/hr and the direction was going in to the Davao City Proper.
- Peak time for vehicles going in to the city was from 7:00 to 8:00 while for going out of the city was from 17:00 to 20:00.

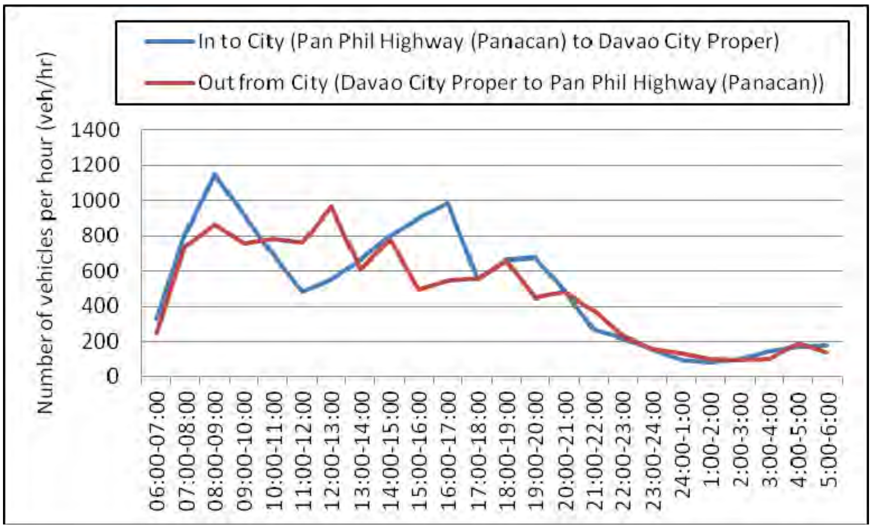


Source: JICA Study Team

FIGURE 6.1-11 HOURLY TRAFFIC VARIATION AT CABANTIAN ROAD

Station 10: CP Garcia (West of Pan Philippine Highway)

- The highest number of passing vehicles was recorded between 8:00 to 9:00 with 1,151 veh/hr and the direction was going in to the Davao City Proper.
- Peak time for vehicles going in to the city was from 7:00 to 8:00 while for going out of the city was from 17:00 to 20:00.

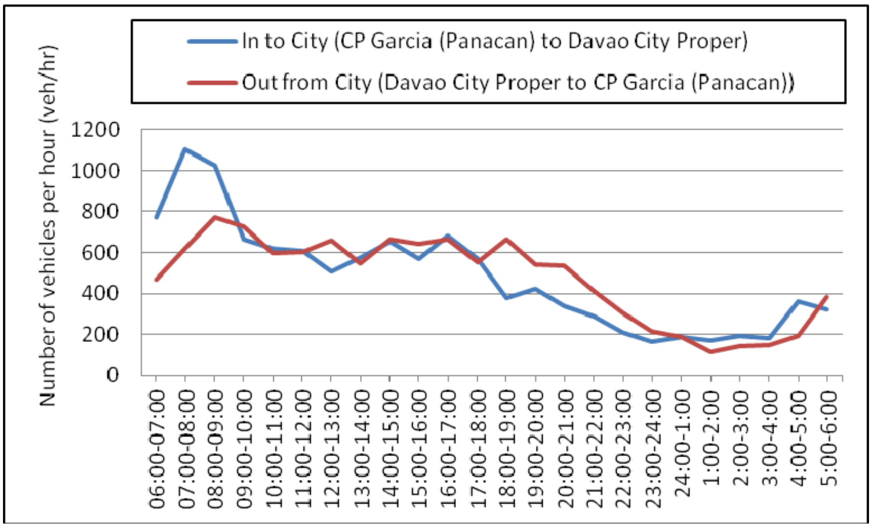


Source: JICA Study Team

FIGURE 6.1-12 HOURLY TRAFFIC VARIATION AT CP GARCIA (WEST OF PAN PHILIPPINE HIGHWAY)

Station 11: Pan Philippine Highway (South of CP Garcia)

- The highest number of passing vehicles was recorded between 7:00 to 8:00 with 1,101 veh/hr and the direction was going in to the Davao City Proper.
- Peak time for vehicles going in to the city was from 7:00 to 9:00 while for going out of the city was from 8:00 to 9:00.

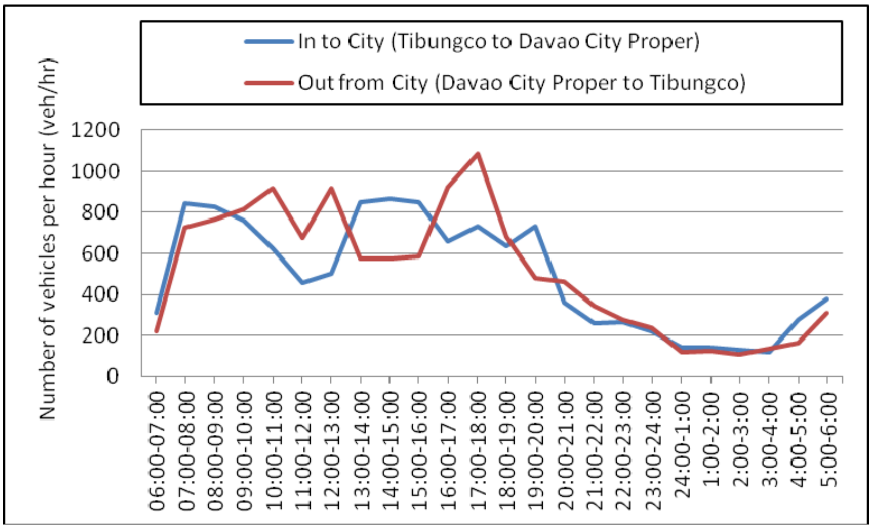


Source: JICA Study Team

FIGURE 6.1-13 HOURLY TRAFFIC VARIATION AT PAN PHILIPPINE HIGHWAY (SOUTH OF CP GARCIA)

Station 12: Pan Philippine Highway (Tibungco)

- The highest number of passing vehicles was recorded between 17:00 to 18:00 with 1,087 veh/hr and the direction was going out of the Davao City Proper.
- Peak time for vehicles going in to the city was from 14:00 to 15:00 while for going out of the city was from 17:00 to 16:00.

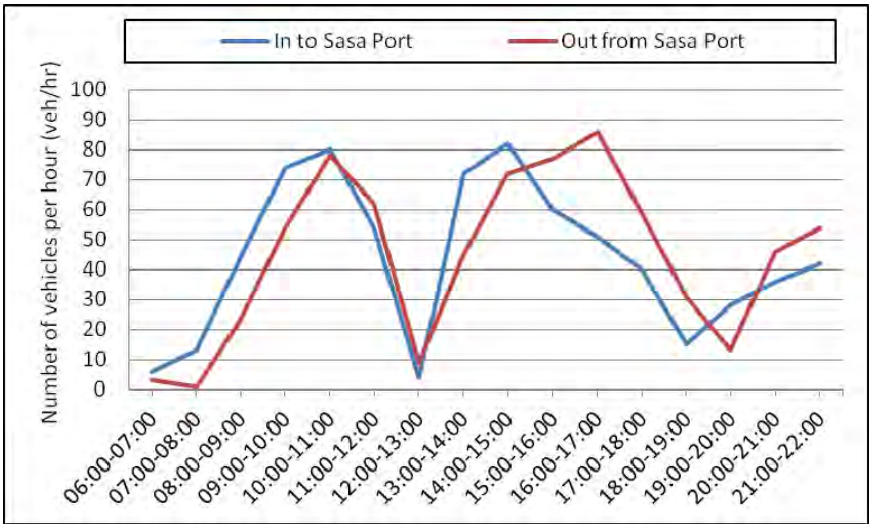


Source: JICA Study Team

FIGURE 6.1-14 HOURLY TRAFFIC VARIATION AT PAN PHILIPPINE HIGHWAY (TIBUNGCO)

Station 13: Sasa Port

- A 16-hour traffic count survey was conducted at the Sasa Port. The highest number of vehicles was recorded between 16:00 to 17:00 with 86 veh/hr and the direction was going out of the Sasa Port.
- Peak time for vehicles going in to the port was from 14:00 to 15:00 while for going out of the port was from 16:00 to 17:00.



Source: JICA Study Team

FIGURE 6.1-15 HOURLY TRAFFIC VARIATION AT SASA PORT

6.1.4 Traffic Composition

Traffic composition is primarily classified into private cars/taxi/van, jeepney, buses, trucks and tricycles/motorcycles. It is noteworthy that along the north and south of Mc Arthur and Diversion Roads, passing truck percentage is almost 20% while at the city roads passing trucks percentage is barely 5%. This is brought about by the truck ban at a certain time frame at the city roads, thus diverting all the truck traffic to Mc Arthur and Diversion Roads.

Mc Arthur Highway

- Composition of vehicular traffic passing along the Mc Arthur Highway is dominated mainly of private cars/taxi/van; 35.03% at Mc Arthur Highway (South of Apo Golf and Country

Club), 42.67% from the North (Davao-Bukidnon Road), and 44% from the East of Catalunan Grande Road. (see **Figure 6.1-16** and **Figure 6.1-18**)

CP Garcia

- Composition of vehicular traffic passing along CP Garcia is likewise dominated mainly of private cars/taxi/van; 47.91% from the East of Catalunan Grande Road), 49.27% from the East of Ma-a Road, 44% from the East of Catalunan Grande Road and 43.69% at the West of Pan Philippine Highway. (see **Figure 6.1-19, Figure 6.1-22** and **Figure 6.1-25**).

Pan Philippine Highway

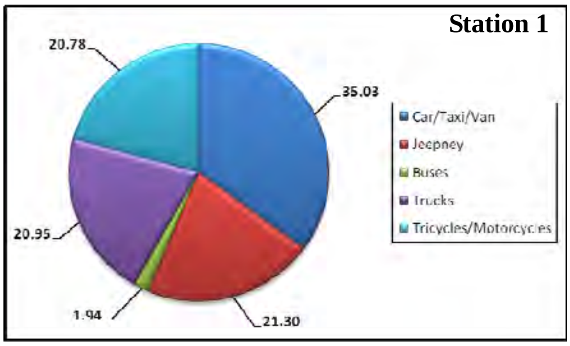
- Vehicular traffic passing along the Pan Philippine Highway is a mixed up of car/taxi/van, jeepneys, trucks and tricycles/motorcycles. Passing trucks percentage (17.11% and 21.22%) in this highway is high because of the presence of the nearby Sasa Port (see **Figure 6.1-26** to **Figure 6.1-27**).

Bolton Bridge

- Almost half (49.07%) of the vehicular traffic passing through the Bolton Bridge is composed of car/taxi/van, while nearly half (47%) is composed of jeepneys and tricycles/motorcycles, while a meager 4.04% is composed of trucks and buses (3.05% and 0.99% respectively). (see **Figure 6.1-20**).

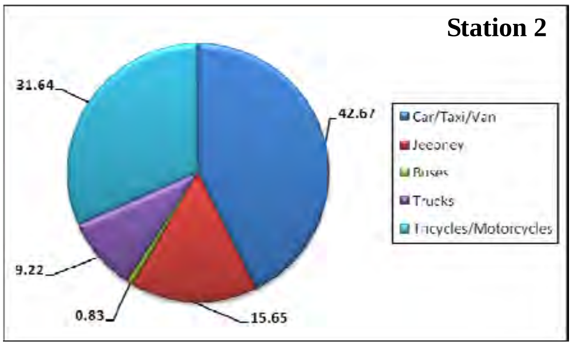
Dacudao Avenue

- This avenue connects CP Garcia and JP Laurel St. The vehicular traffic passing along Dacudao Avenue is dominated by 40.06% car/taxi/van, 30.09% jeepneys, and 20.24% tricycles/motorcycles. (see **Figure 6.1-23**).



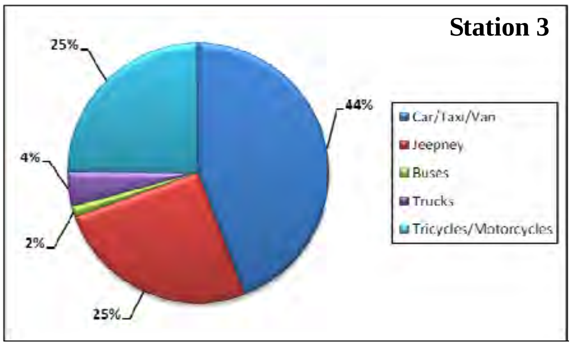
Source: JICA Study Team

FIGURE 6.1-16 TRAFFIC COMPOSITION AT MC ARTHUR HIGHWAY (SOUTH OF APO GOLF AND COUNTRY CLUB)



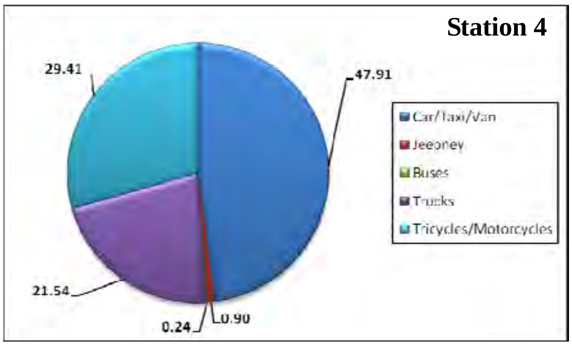
Source: JICA Study Team

FIGURE 6.1-17 TRAFFIC COMPOSITION AT DAVAO – BUKINDON ROAD (NORTH OF MC ARTHUR HIGHWAY)



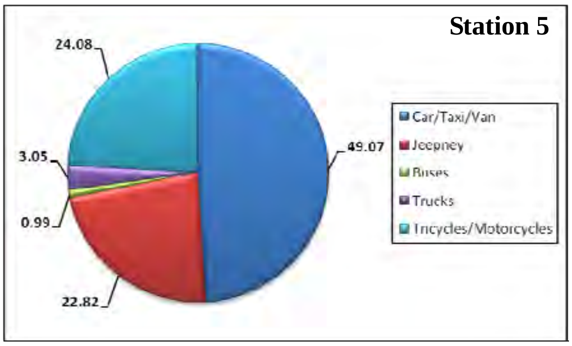
Source: JICA Study Team

FIGURE 6.1-18 TRAFFIC COMPOSITION AT MAC ARTHUR HIGHWAY (EAST OF CATALUNAN GRAND ROAD)



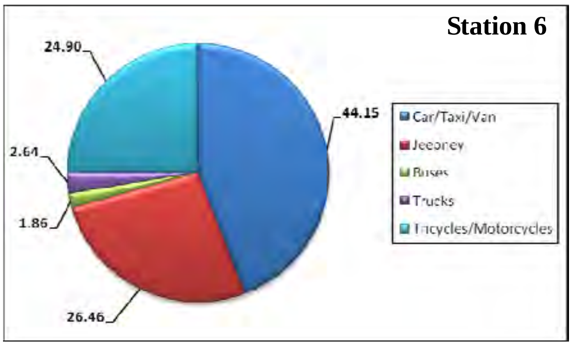
Source: JICA Study Team

FIGURE 6.1-19 TRAFFIC COMPOSITION AT CP GARCIA (EAST OF CATALUNAN GRAND ROAD)



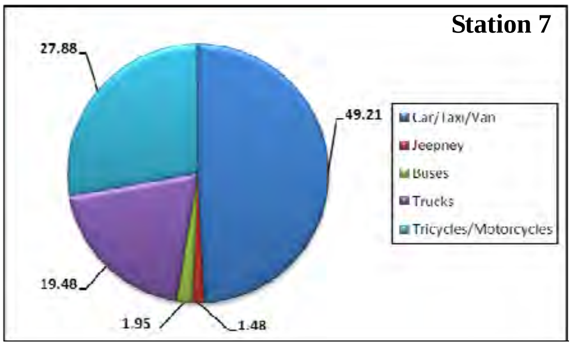
Source: JICA Study Team

FIGURE 6.1-20 TRAFFIC COMPOSITION AT BOLTON BRIDGE



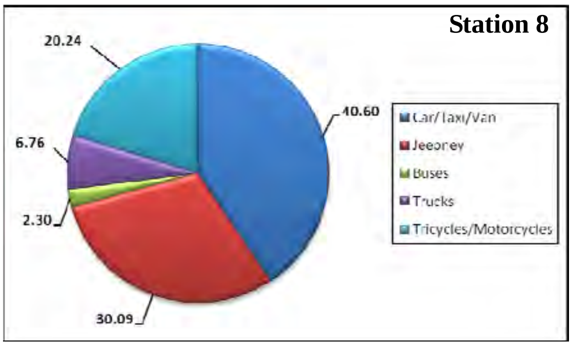
Source: JICA Study Team

FIGURE 6.1-21 TRAFFIC COMPOSITION AT BANKEROHAN BRIDGE



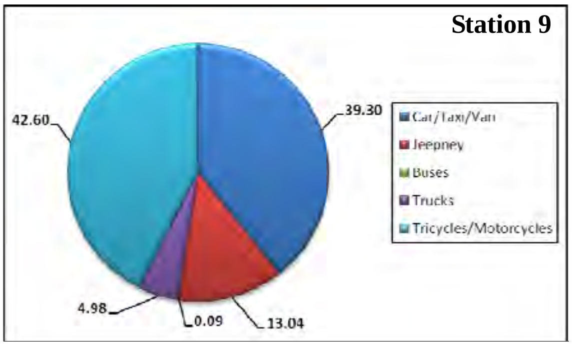
Source: JICA Study Team

FIGURE 6.1-22 TRAFFIC COMPOSITION AT CP GARCIA (EAST OF MA-A ROAD)



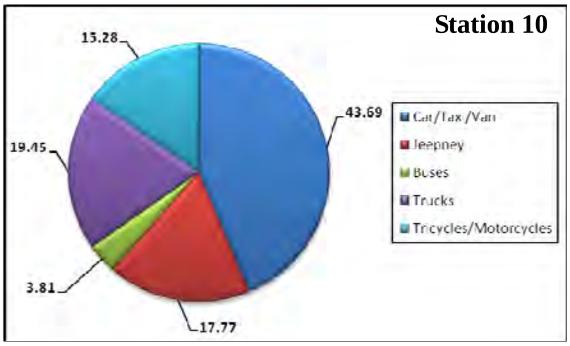
Source: JICA Study Team

FIGURE 6.1-23 TRAFFIC COMPOSITION AT DACUDAO AVENUE



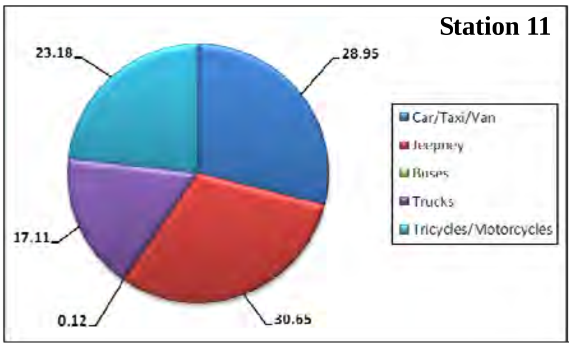
Source: JICA Study Team

FIGURE 6.1-24 TRAFFIC COMPOSITION AT CABANTIAN ROAD



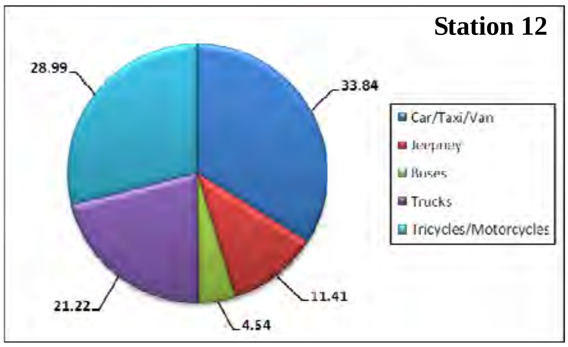
Source: JICA Study Team

FIGURE 6.1-25 TRAFFIC COMPOSITION AT CP GARCIA (WEST OF PAN PHILIPPINE HIGHWAY)



Source: JICA Study Team

FIGURE 6.1-26 TRAFFIC COMPOSITION AT PAN PHILIPPINE HIGHWAY (SOUTH OF CP GARCIA)



Source: JICA Study Team

FIGURE 6.1-27 TRAFFIC COMPOSITION AT PAN PHILIPPINE HIGHWAY (TIBUNGCO)

6.1.5 Summary of Roadside Interview Survey Results

Table 6.1-2 shows the accomplishment of Roadside Interview Survey. Total sample was 3,572 including truck interview conducted at Sasa Port.

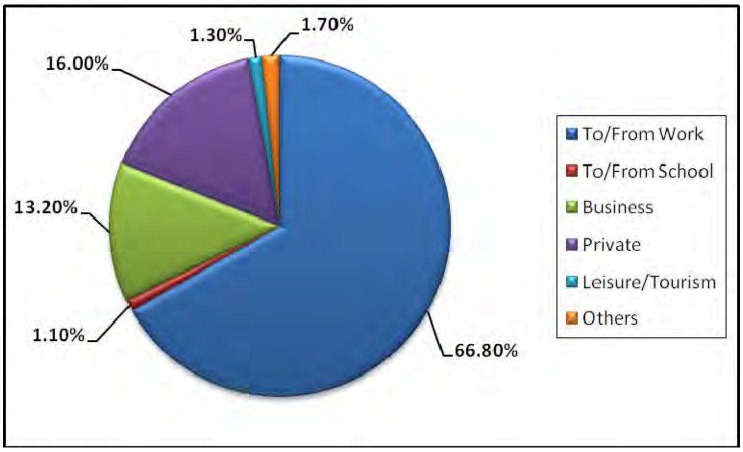
TABLE 6.1-2 ACCOMPLISHMENT OF ROAD SIDE INTERVIEW SURVEY

Code	Station	Vehicle/day	No. of Samples	Sample Rate
1-OD	Mc Arthur (Toril)	11,066	666	6.02%
2-OD	Davao-Bukidnon Road	8,940	1,145	12.81%
3-OD	Pan Philippine Highway (Lasang)	13,623	939	6.89%
T-OD	Sasa Port	1,414	822	58.13%
		Total = 3,572		

Source: JICA Study Team

(1) Trip Purpose

Of the total vehicle trips, 66.8% were “To/from Work”. This data does not include the Truck OD Survey at Sasa Port.



Source: JICA Study Team

FIGURE 6.1-28 TRIP PURPOSE

(2) Average Number of Passengers by Vehicle Type

Table 6.1-3 shows the average number of passenger on-board by vehicle type.

TABLE 6.1-3 AVERAGE NUMBER OF PASSENGERS BY VEHICLE TYPE

Station	Vehicle Type							Total
	Car/Van / PUV	Jeepney	Mini-bus	Large bus	2-axle Truck	3-axle Truck	Truck/ Trailer	
1-OD	6.47	18.31	17.40	30.75	2.63	2.02	2.37	10.60
2-OD	2.90	9.42	16.50	29.89	2.30	1.92	1.79	7.22
3-OD	5.10	9.99	18.00	30.31	2.33	2.49	2.23	9.60
Average	4.77	10.75	17.25	30.32	2.40	2.11	2.05	6.81

Source: JICA Study Team

(3) Average Commodity Weight and Average Net Load Capacity

Table 6.1-4 shows the average commodity weight and net load capacity. The average commodity weight by truck was 8.5 ton.

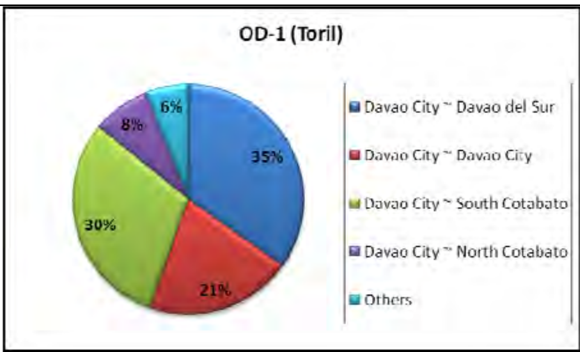
TABLE 6.1-4 AVERAGE COMMODITY WEIGHT AND NET LOAD CAPACITY

Code	Station	Ave. Commodity Weight (kg)	Ave. Net Load Capacity (kg)
1-OD	Mc Arthur (Toril)	12,614	5,921
2-OD	Davao-Bukidnon Road	10,063	6,351
3-OD	Pan Philippine Highway (Lasang)	7,033	6,402
T-OD	Sasa Port	12,617	13,564
Average		8,543	5,268

Source: JICA Study Team

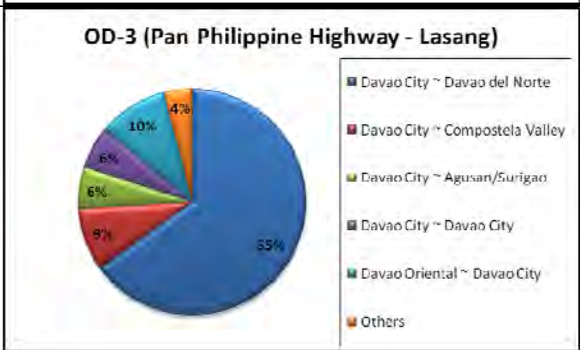
(4) Origin and Destination by Province

Figure 6.1-29 shows the OD at Stations 1,3 and Sasa Port.



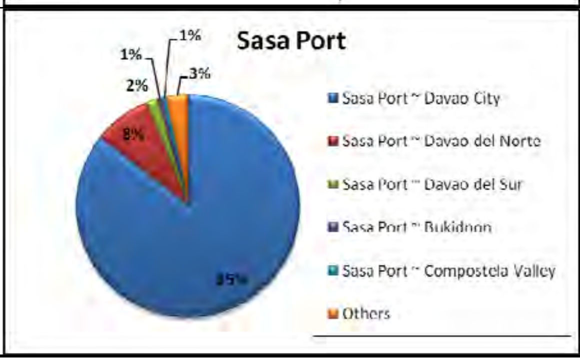
Major OD Trip

Davao del Sur – Davao City
South Cotabato – Davao City



Major OD Trip

Davao del Norte – Davao City



Major OD Trip

Davao City – Sasa Port

Source: JICA Study Team

FIGURE 6.1-29 ORIGIN AND DESTINATION OF VEHICLULAR TRAFFIC

6.1.6 Port, Airport Trips

The following three (3) ports and one (1) airport officials' interview were conducted to know the present cargo volume in terms of number of trucks to be used daily in transporting their respective products.

(1) Airport

Davao City have one international airport, namely Francisco Bangoy International Airport

(Davao International Airport). The number of flights, number of passengers, and cargo traffic are presented in **Table 6.1-5.**

Annual growth rate is high, 6~17% for the number of passengers and 6~18% for cargo movement.

TABLE 6.1-5 NUMBER OF FLIGHTS, NUMBER OF PASSENGERS AND CARGO TRAFFIC

	Year	Domestic	Foreign	Total	Growth Rate
Number of Plane Arrival (times)	2009	7,393	280	7,673	-
	2010	7,720	217	7,937	3.4%
	2011	9,325	284	9,609	21.2%
	2012	10,534	323	10,857	13.0%
Number of Passengers (in thousands)	2009	991	16	1,007	-
	2010	1,115	10	1,125	11.7%
	2011	1,306	15	1,321	17.4%
	2012	1,383	20	1,403	6.2%
Cargo Movement (ton)	2009	34,173	84	34,257	-
	2010	40,569	63	40,632	18.6%
	2011	39,713	55	39,768	-2.1%
	2012	42,119	67	42,186	6.1%

Source: Davao (Francisco Bangoy) International Airport and Philippine Ports Authority

(2) Port

There are three (3) ports in the Study Area, namely Sasa Port, TEFASCO (TErminal FAcilities & Services Corporation) and AJMR Port as shown in **Figure 6.1-30**.

Source: JICA Study Team

FIGURE 6.1-30 LOCATION MAP OF SASA PORT, TEFASCO AND AJMR PORT

1) Sasa Port

Sasa port is served as the container ship, general cargo ship for foreign and domestic cargo. Though it had served as RORO, it was not operated since last year due to decrease of passengers (see **Table 6.1-6**).

TABLE 6.1-6 NO. OF PASSENGERS IN SASA PORT

Year	No. of Passenger
2008	89,168
2009	71,673
2010	62,220
2011	26,643
2012	No operation

Source: Philippine Ports Authority

Sasa Port was used about one thousand vessels per year shown in **Table 6.1.6-3**.

TABLE 6.1-7 NUMBER OF VESSEL ARRIVAL AT SASA PORT

Year	Domestic	Foreign	Total
2008	519	370	889
2009	510	459	969
2010	550	515	1065
2011	496	568	1064
2012	435	438	873

Source: Philippine Ports Authority

Table 6.1-9 shows the volume of cargo handled by commodity type. A foreign volume was 2.94 million ton and a domestic volume was 2.15, total volume was 5.095 million ton in 2012.

Major commodities are Fruits and Vegetables Products (CT05), Pulp and Paper Products (CT23), Metal Ores Products and Scraps (CT15), Grains (CT04), Fertilizer (CT14) and etc.

Table 6.1-8 shows the container traffic by month. April was the busiest month at Sasa Port and August, September which conducted by traffic count were off peak month.

TABLE 6.1-8 MONTHLY CONTAINER TRAFFIC AT SASA PORT

Month	Container Traffic (TEU)	Monthly Variation
JAN	44,167	1.06
FEB	40,518	0.97
MAR	41,933	1.01
APR	46,364	1.11
MAY	44,143	1.06
JUN	37,839	0.91
JUL	41,148	0.99
AUG	36,851	0.88
SEP	39,844	0.96
OCT	42,966	1.03
NOV	40,717	0.98
DEC	43,801	1.05
TOTAL	**500,288**	

Source: Philippine Ports Authority

TABLE 6.1-9 VOLUME OF COMMODITY TYPE AT SASA PORT (YEAR 2012)

Unit: Ton

CODE	COMMODITY NAME	Foreign	Domestic	Total
CT 01	Live Animals	0	2,432	2,432
CT 02	Meat, Dairy Prods & Eggs	1,920	14,384	16,304
CT 03	Fish and Fish Prep	2,193	15,627	17,820
CT 04	Grains	95,189	146,257	**241,446**
CT 05	Fruits and Vegtbls Prods	1,228,422	29,680	**1,258,102**
CT 06	Sugar Cane and By-Prods	18,222	7,465	25,687
CT 07	Animal Feeds	20,713	25,857	46,570
CT 08	Bottled Cargo	-	116,890	**116,890**
CT 09	Tobacco and Manf	-	18	18
CT 10	Coconut and By-Prods	78,243	38,263	**116,506**
CT 11	Wood and By-Prods	57,928	72,671	**130,599**
CT 12	Abaca	3,123	1,568	4,691
CT 13	Textile and Like Prods	2,032	2,642	4,674
CT 14	Fertilizer	123,126	47,049	**170,175**
CT 15	Metal Ores, Prods & Scraps	64,688	214,501	**279,189**
CT 16	Fuel and By-Prods	2,824	14,987	17,811
CT 17	Chems and Related Prods	109,527	31,738	**141,265**
CT 18	Cement	25	108,284	**108,309**
CT 19	Mach & Elctl. Eqpmnt	17,912	21,055	38,967
CT 20	Crude Minerals	56,169	3,864	60,033
CT 21	Transport Eqpt Parts and Acc	6,156	86,510	92,666
CT 22	Furniture	10,553	10,037	20,590
CT 23	Pulp and Paper Prods	235,012	83,973	**318,985**
CT 24	Other General Cargo	618,010	1,056,428	**1,674,438**
-	Tires	5,943		5,943
-	Ceramic Tiles	116,415		**116,415**
-	UKAY-UKAY	34,237		34,237
-	Rubber Cuplump	34,241		34,241
	TOTAL	**2,942,823**	**2,152,180**	**5,095,003**

Source: Philippine Ports Authority

2) TEFASCO

TEFASCO Port is operated by private company for container ship and general cargo ship. TEFASCO was used more than three hundred vessels per year shown in **Table 6.1-10**.

TABLE 6.1-10 NUMBER OF VESSEL ARRIVAL AT TEFASCO

Year	Domestic	Foreign	Total
2008	196	139	335
2009	186	125	311
2010	188	134	322
2011	198	132	330
2012	219	189	405

Source: Philippine Ports Authority

Table 6.1-11 shows the volume of cargo handled by commodity type. Major commodities are Fertilizer, Banana, Sugar, Salt, Rice, Cement etc.

TABLE 6.1-11 VOLUME OF COMMODITY TYPE AT TEFASCO

Unit: Ton

Commodity Type	Incoming Cargo		Outgoing Cargo	
	Domestic	Foreign	Domestic	Foreign
Fertilizer	10,880	275,686	8,290	-
Rice	6,058	102,343	9,883	-
Banana	-	-	-	64,240
Salt	-	41,344	-	-
Sugar	-	-	-	30,149
Plywood	-	-	13,682	-
Cement	13,375	-	-	-
Logs	-	9,795	-	-
Soya Bean Meal	7,153	-	-	-
Container	548,420	106,740	437,840	136,580
Total	**585,886**	**535,908**	**469,695**	**230,969**

Source: Philippine Ports Authority

3) AJMR Port

AJMR Port is operated by private company for container ship and refrigerated ship from/to only domestic. **Table 6.1-12** shows the number of vessel arrival and volume of cargo.

TABLE 6.1-12 VESSEL ARRIVAL AND VOLUME OF CARGO AT AJMR PORT

Year	Vessel Arrival	Volume of Cargo(Ton)
2008	154	402,543
2009	130	186,574
2010	124	237,799
2011	181	407,538
2012	201	461,564

Source: Philippine Ports Authority

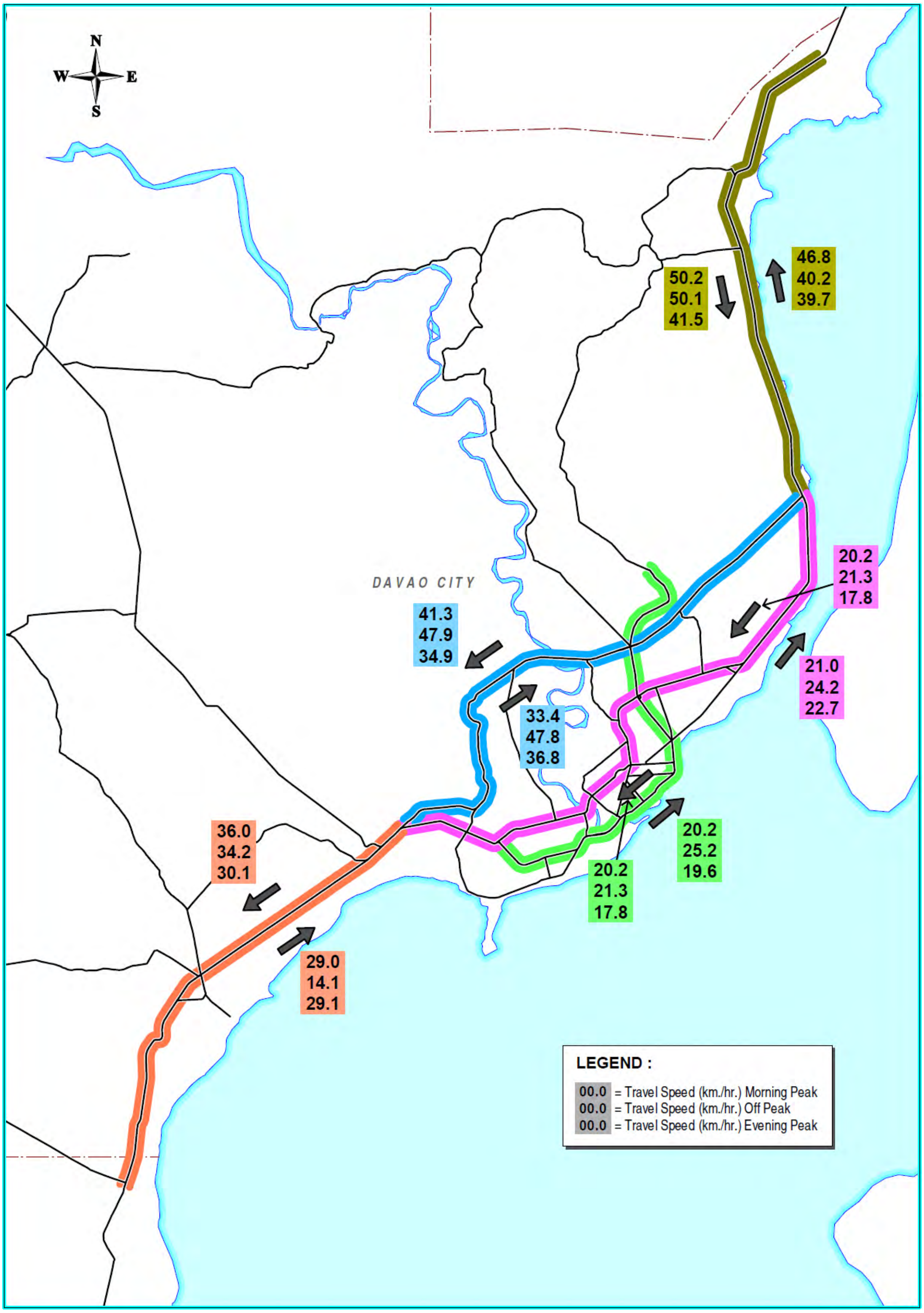
Major outgoing cargo from this port is Banana, Pineapple and Papaya.

6.1.7 Travel Time Survey

Travel Time Survey was carried out to identify the actual travel time and speed along Mc. Arthur Highway, Pan-Philippine Highway, Diversion Road, and the city road. Survey time was during the morning peak (07:00-09:00A.M), off peak (01:00-03:00P.M.) and evening peak (04:30-06:30P.M) on a week day.

Figure 6.1-31 shows the average travel speed.

North Section :	Travel speed was around 40~50km/hr, high speed
South Section :	Travel speed was around 30km/hr, moderate (off-peak, north direction was congested due to construction works, etc.)
Center Section :	Travel speed along Diversion Road was 35~45km/hr, high speed. Travel speed along JP Laurel Ave. was around 20km/hr from morning peak to evening peak, low speed. Travel speed along Quimpo Blvd., Dacudao Ave. was also around 20km/hr from morning peak to evening peak, low speed.

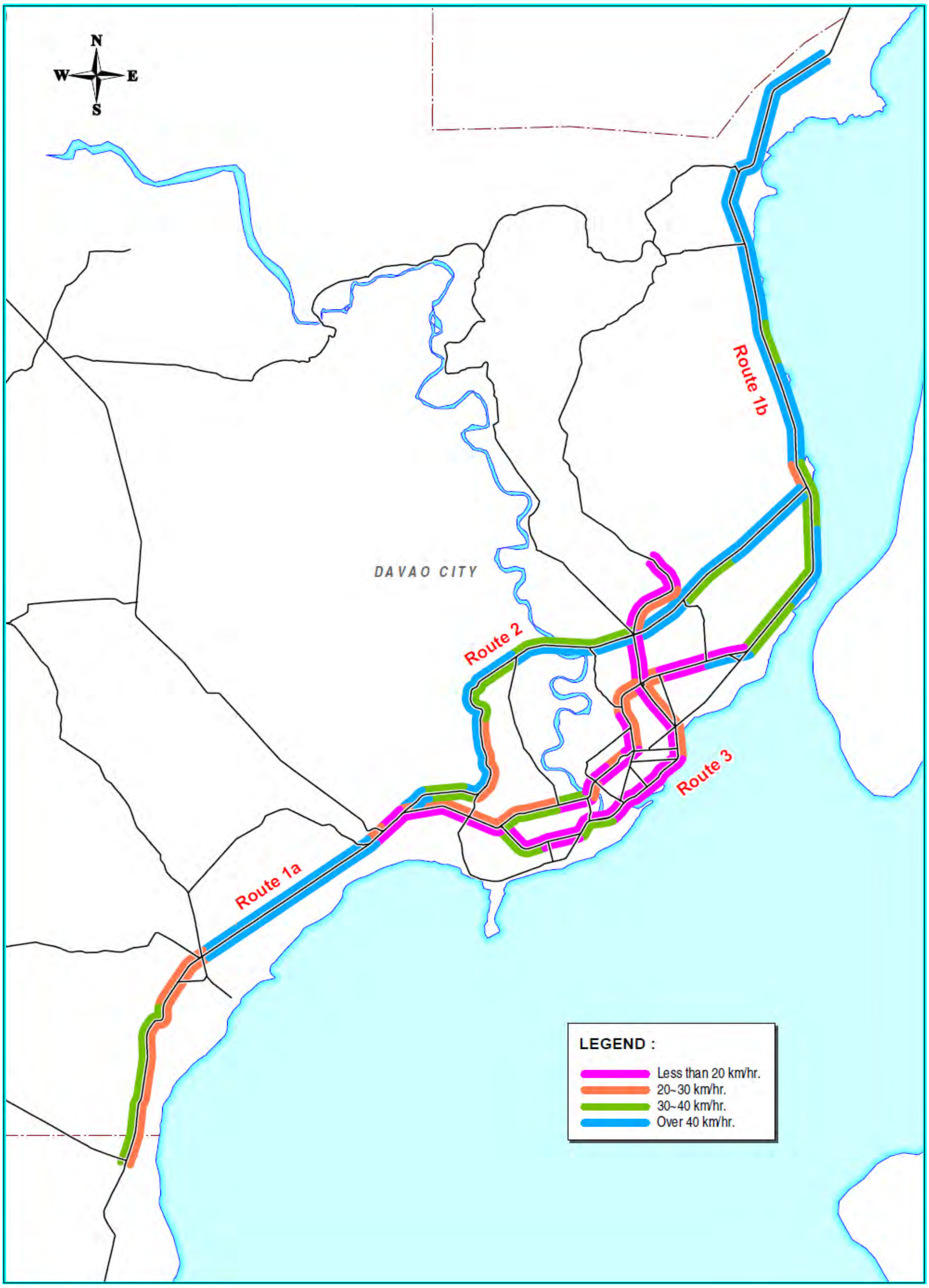


Source: JICA Study Team

FIGURE 6.1-31 AVERAGE SPEED OF MAJOR CORRIDOR

Figure 6.1-32 (1) ~ (3) shows the travel speed condition during morning peak, off peak and evening peak hours.

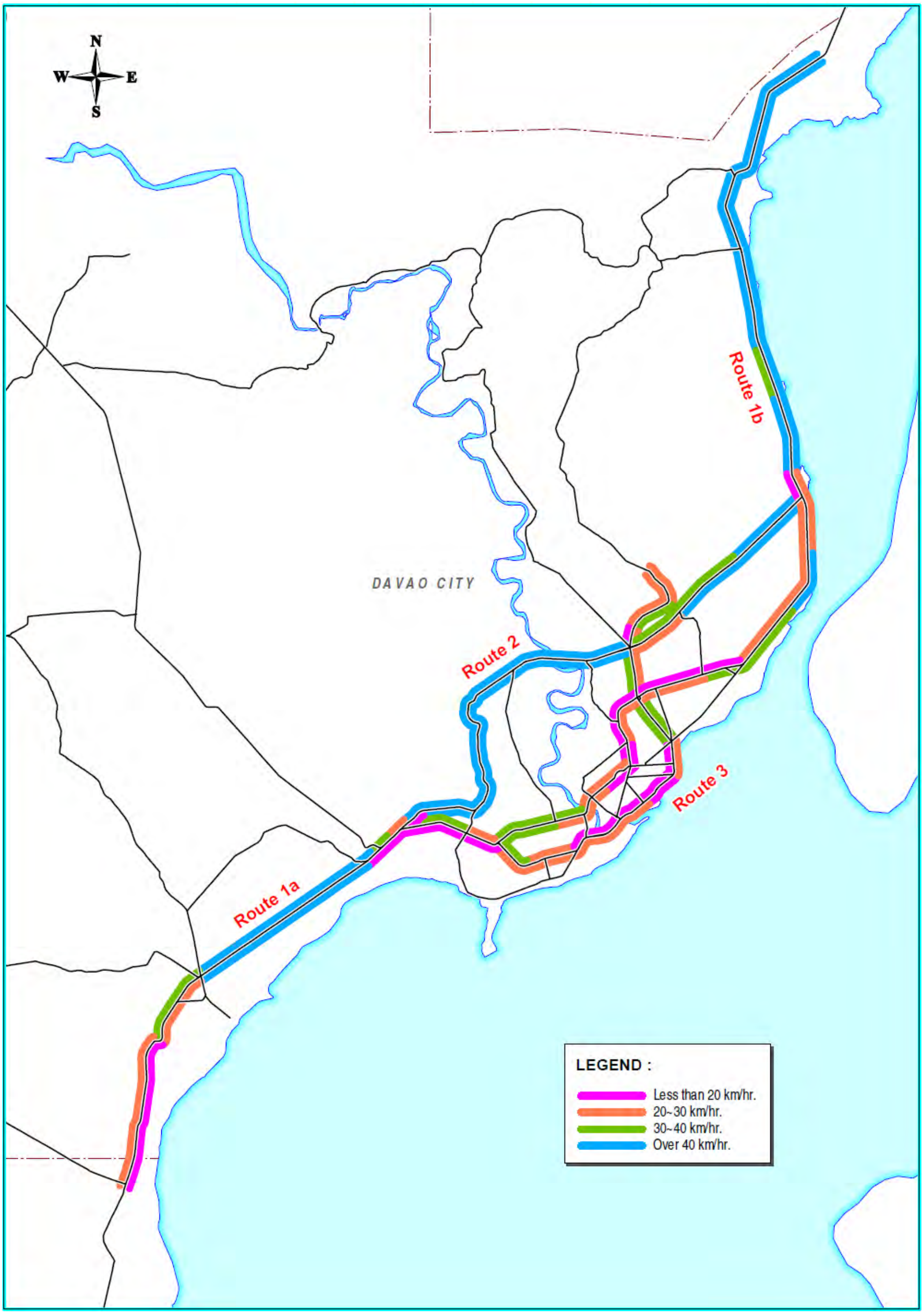
<u>Morning Peak:</u> Many roads in the City Center are very crowded; especially direction coming from the south to the City Center has a long low-speed section as shown in the figure.



Source: JICA Study Team

FIGURE 6.1-32 (1) TRAVEL SPEED OF MAJOR CORRIDORS IN DAVAO CITY (MORNING PEAK HOURS (07:00-09:00A.M))

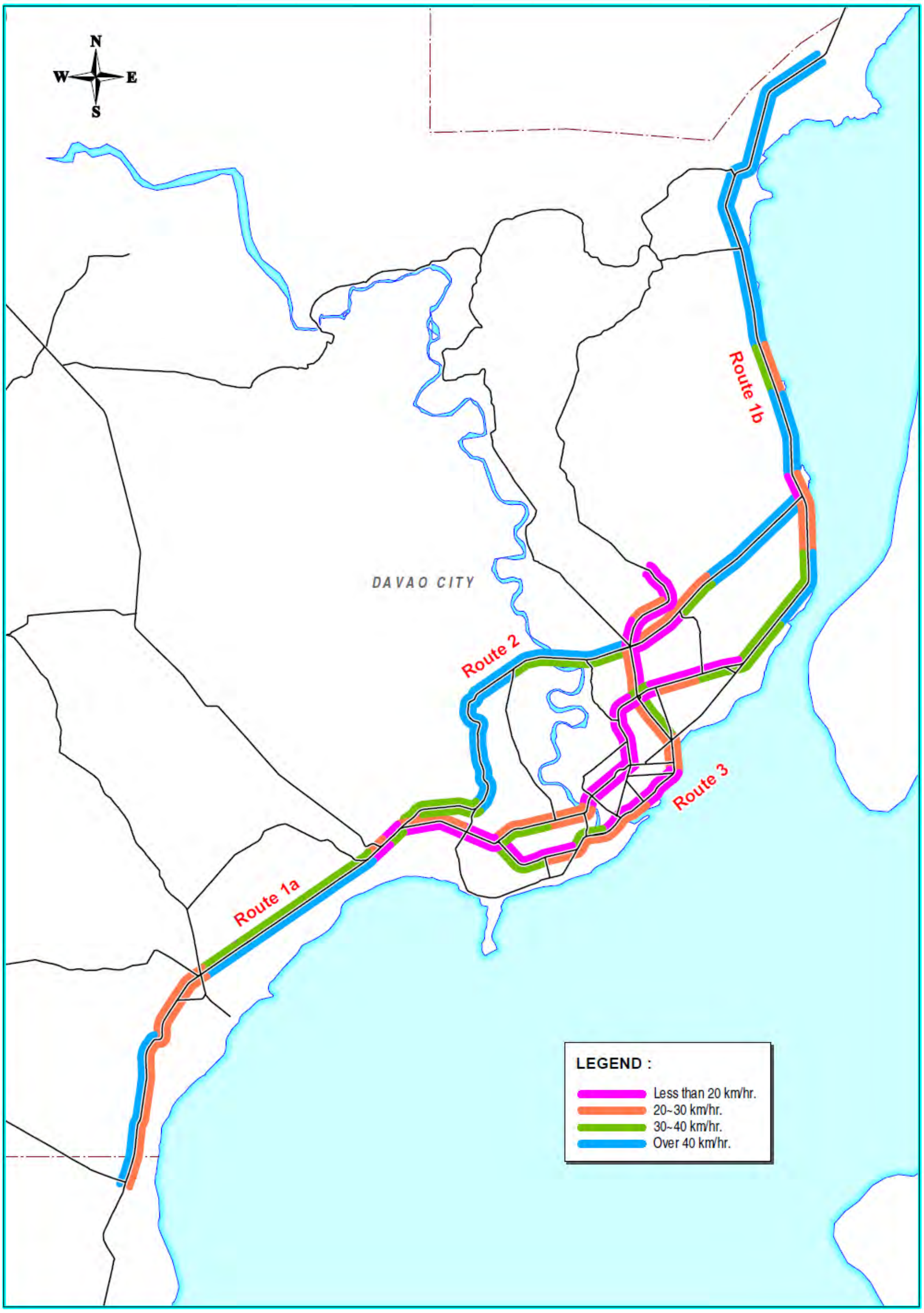
Off-peak: Relatively lesser congested section than the morning peak, travel speed along Diversion Road was almost over 40km/hr.



Source: JICA Study Team

FIGURE 6.1-32 (2) TRAVEL SPEED OF MAJOR CORRIDORS IN DAVAO CITY (OFF PEAK HOURS (01:00-03:00P.M))

Evening Peak: JP Laurel Ave. was congested, especially City Center area, both for the north and south direction. Diversion Road was also observed to be with less than 20km/hr section during the evening peak.



Source: JICA Study Team

FIGURE 6.1-32 (3) TRAVEL SPEED OF MAJOR CORRIDORS IN DAVAO CITY (EVENING PEAK (04:30-06:30P.M))

6.2 FUTURE TRAFFIC DEMAND

6.2.1 Approach

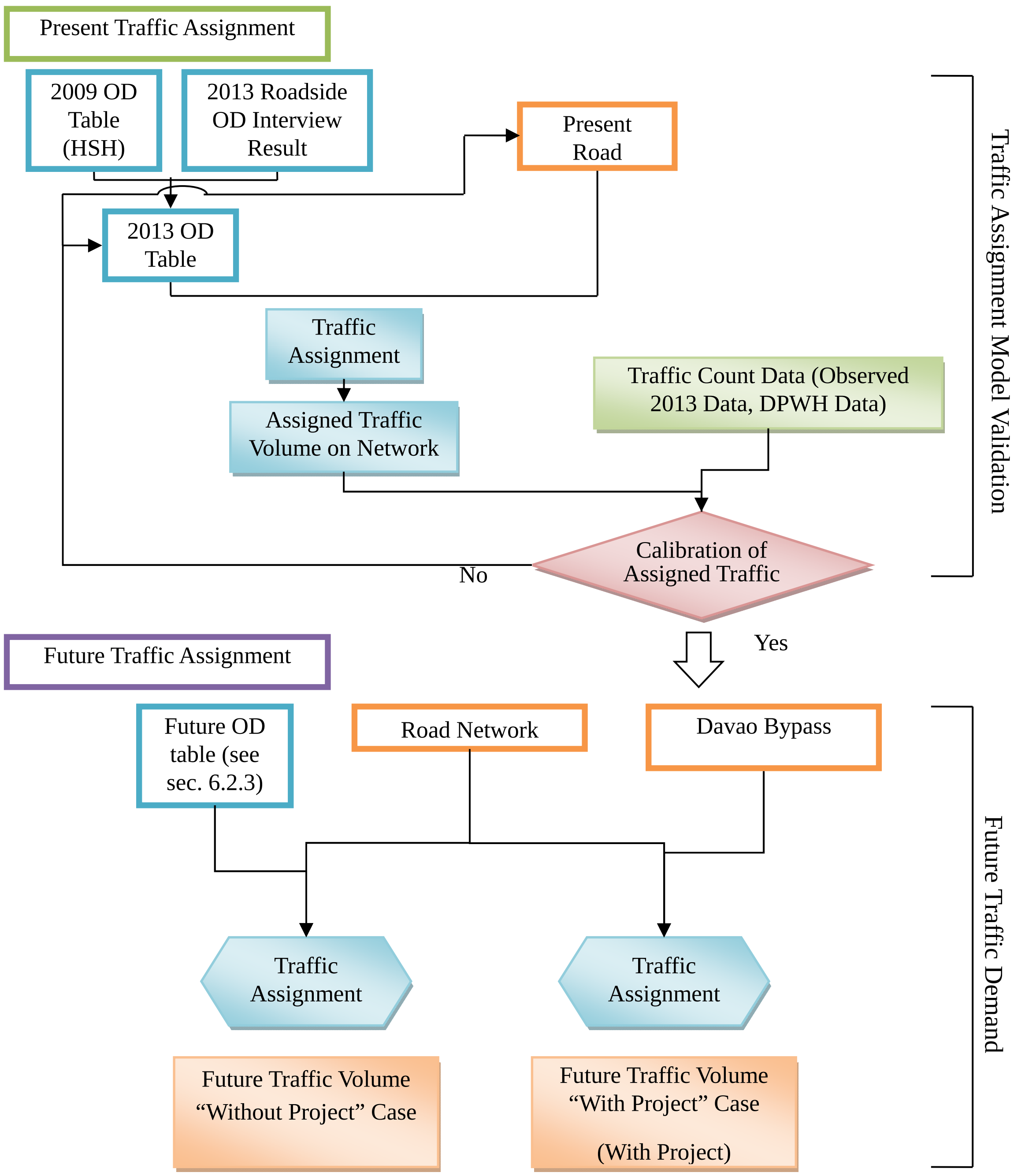
To estimate the traffic volumes on Davao Bypass, traffic demand forecast was conducted. **Figure 6.2-1** shows the traffic forecast procedure.

(1) Present Traffic Assignment

Based on analyzed roadside interview survey result in this project and year 2009 OD tables prepared by the Study of Master Plan on High Standard Highway Network Development (herein HSH Study), the present OD table was prepared and updated as year 2013. Traffic assignment was conducted using the present OD table and present road network, and then validation was conducted for the traffic count data (i.e. traffic survey result and year 2012 traffic volume carried out by DPWH for statistics) and assigned traffic volume on each link.

(2) Future Traffic Assignment

After validation of present OD table, future traffic demand was forecasted. Future traffic assignment was conducted using future OD table and future road network (with Bypass Project Case and Without Project Case).



Source: JICA Study Team

FIGURE 6.2-1 FORECAST OF TRAFFIC VOLUMES ON ROAD NETWORK

In this traffic assignment, the zoning system is comprised of Davao City, and Mindanao Island (Region 9, 10, 11, 12, 13, and ARRM). The zoning system is modified as divided zoning in the Davao City area using that of the HSH Study. The total zoning number is 59 zones as shown in **Figure 6.2-2** to **Figure 6.2-3** and **Table 6.2-1** to **Table 6.2-2**.

TABLE 6.2-1 TRAFFIC ZONING SYSTEM IN DAVAO CITY AREA

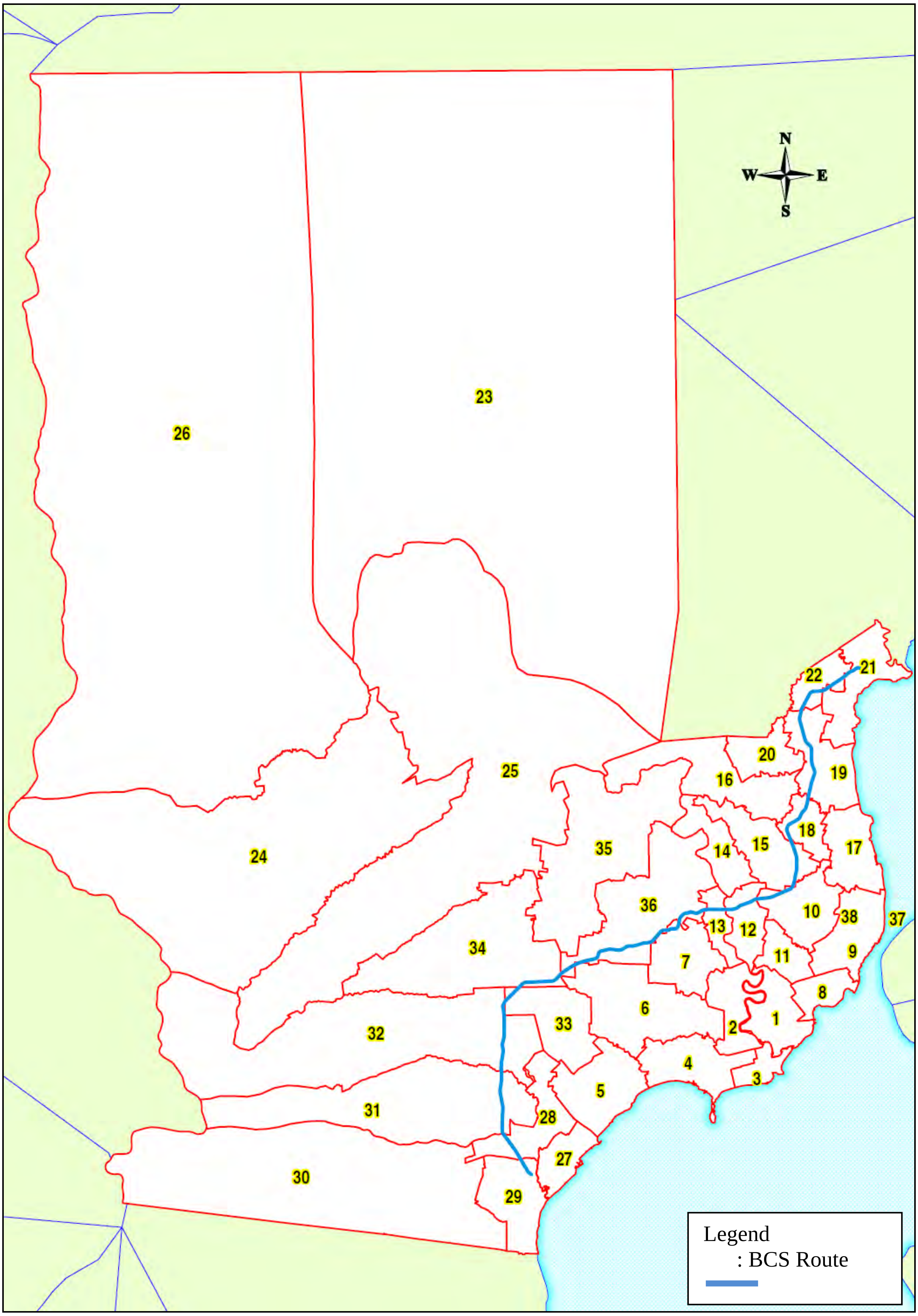
Zone No.	Barangay	District
1	Barangay 1-A (Pob.) ~ Barangay 10-A (Pob.)	POBLACION
	Barangay 11-A (Pob.) ~ Barangay 20-B (Pob.)	
	Barangay 21-C (Pob.) ~ Barangay 30-C (Pob.)	
	Barangay 31-D (Pob.) ~ Barangay 40-D (Pob.)	
2	Ma-a	TALOMO
3	Bucana	
4	Matina Aplaya, Matina Crossing, Talomo (Pob.)	
5	Bago Aplaya, Bago Gallera, Langub, Baliok, Dumoy	
6	Catalunan Grande, Catalunan Pequeño, Matina Pangi	
7	Magtuod	
8	Agdao, Centro (San Juan), Gov. Paciano Bangoy, Gov. Vicente Duterte	AGDAO
	Kap. Tomas Monteverde, Sr. , Lapu-lapu, Leon Garcia, Sr. , Rafael Castillo	
	San Antonio, Ubalde, Wilfredo Aquino	
9	Alfonso Angliongto Sr., Pampanga, Sasa, Vicente Hizon Sr.	BUHANGIN
10	Cabantian, Communal	
11	Buhangin (Pob.),	
12	Tigatto	
13	Waan	
14	Acacia, Callawa	
15	Indangan	
16	Mandug	
17	Ilang, Panacan	BUNAWAN
18	Mudiang	
19	Gatungan	
20	Mahayag, Tibungco	
21	Alejandra Navarro (Lasang), Bunawan (Pob.)	
22	San Isidro (Licanan)	
23	Colosas , Fatima (Benowang), Lumiad, Mabuhay, Malabog, Mapula	PAQUIBATO
	Panalum, Pandaitan, Paquibato (Pob.), Paradise Embak	
	Salapawan, Sumimao, Tapak	
24	Baguio (Pob.), Cadalian, Carmen, Gumalang	BAGUIO
	Malagos, Tambobong, Tawan-tawan, Wines	
25	Biao Joaquin, Calinan (Pob.), Cawayan, Dacudao, Dalagdag , Dominga	CALINAN
	Inayangan, Lacson, Lamanan, Lampianao, Megkawayan, Pangyan	
	Talomo River, Tamayong, Saloy, Sirib, Subasta, Riverside, Wangan	
26	Baganihan, Bantol, Buda, Dalag, Datu Salumay, Gumitan, Magsaysay	MARILOG
	Malamba, Marilog, Salaysay, Suawan (Tuli), Tamugan	
27	Daliao, Lizada, Lubogan, Marapangi	TORIL
28	Bangkas Heights, Binugao, Toril (Pob.)	
29	Camansi, Sirawan	
30	Atan-Awe, Baracatan, Crossing Bayabas, Sibulan, Tibuloy	
31	Bato, Bayabas, Eden, Kilate, Tagurano	
32	Alambre, Catigan, Daliaon Plantation, Mulig, Tagluno, Tungakalan	
33	Bago Oshiro, Mintal, Santo Niño	TUGBOK
34	Angalan, Balengaeng, Los Amigos, Manambulan, Manuel Guianga	
	Tagakpan, Tugbok (Pob.)	
35	Biao Escuela, Biao Guianga, New Valencia, Talandang, Ula	
36	Matina Biao, New Carmen, Tacunan	
37	SASA PORT	OTHERS
38	DAVAO AIRPORT	OTHERS

Source: JICA Study Team

TABLE 6.2-2 TRAFFIC ZONING SYSTEM OUTSIDE DAVAO CITY AREA

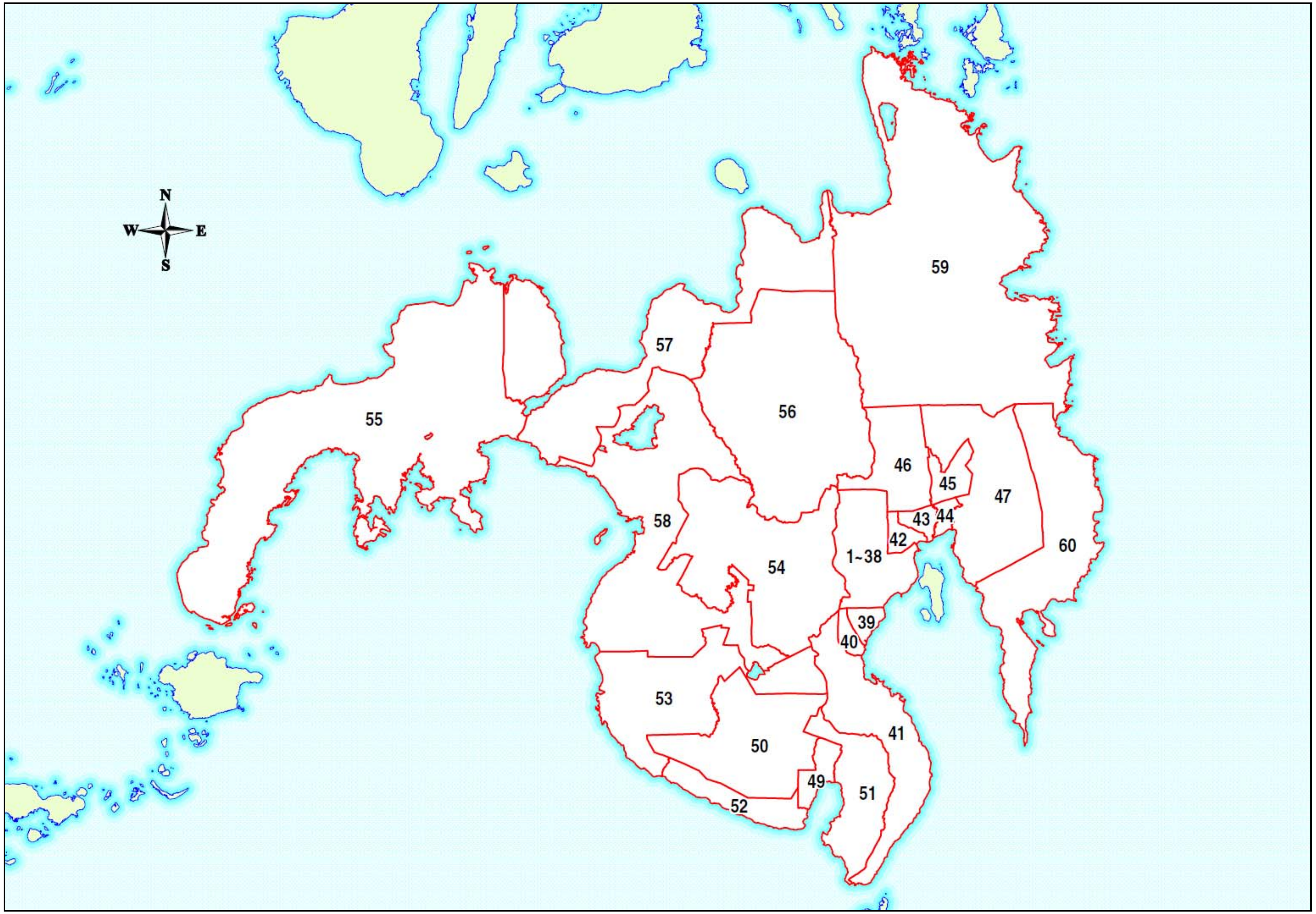
Zone No.	City/Municipality	Province	Region
39	Santa Cruz	Davao del Sur	Region XI
40	City of Digos		
41	Bansalan, Hagonoy, Kablaway, Magsaysay, Malalag, Malita, Matanao, Padada, Santa Maria, Sulop, Jose Abad Santos, Don Marcelino		
42	City of Panabo	Davao del Norte	
43	Carmen, Braulio Dujali		
44	City of Tagum		
45	Asuncion, New Corella		
46	Kapalong, Santo Tomas, Talaingod		
47	-	Compostela Valley	
48	-	Davao Oriental	
49	General Santos City	South Cotabato	Region XII
50	Polomolok, Tboli, Banga, City of Koronadal, Norala, Surallah, Tampakan, Tantangan, Tupi, Snto Nino, Lake Sebu		
51	Alabel, Malungon, Malapatan, Glan	Sarangani	
52	Maitum, Kiamba, Massim	-	
53	-	Sultan Kudarat	
54	-	Cotabato (North Cotabato)	
55	-	Zamboanga Del Norte, Zamboanga Del Sur, Zamboanga Sibugay	Region IX
56	-	Bukidnon	Region X
57	-	Lanao del Norte, Misamis Occidental, Misamis Oriental	
58	-	Cotabato City, Lanao del Sur, Maguindanao, Shariff Kabunsuan	Region XIV
59	-	Agusan del Sur, Agusan del Norte, Surigao del Norte, Surigao del Sur	Region XIII

Source: JICA Study Team



Source: JICA Study Team

FIGURE 6.2-2 ZONING MAP IN DAVAO CITY



Source: JICA Study Team

FIGURE 6.2-3 ZONING MAP OUTSIDE DAVAO CITY

6.2.2 Future Socio-economic Framework

The future socio-economic framework indicators were formulated by the national statistics data of National Statistics Office (NSO) and Davao City Planning and Development Office (DCPDO). Future socio-economic framework was revised considering the current development direction and the nature of each private developer in the Study Area by the JICA Study Team. The future socio-economic profile is summarized below.

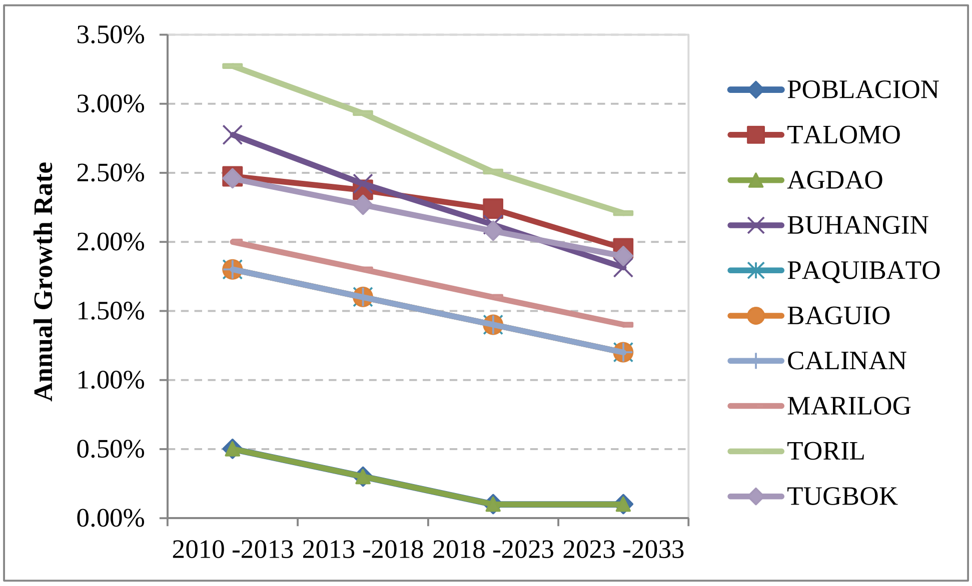
(1) Population Projection

The population of Davao City is based on the acquired data from private developers and the land use plan of Davao City Planning and Development Office. On the other hand, outside Davao City area is revised based on the statistical data of NSO.

Figure 6.2-4 shows the annual growth rate of population projection from 2010 to 2033 in Davao City and **Table 6.2-3** shows the summarized population projection considered in the development plan of Davao City. Average growth rate in Davao City is 2.00% from year 2013 to year 2018, 1.80% from year 2018 to 2023 and 1.60% from year 2023 to year 2033.

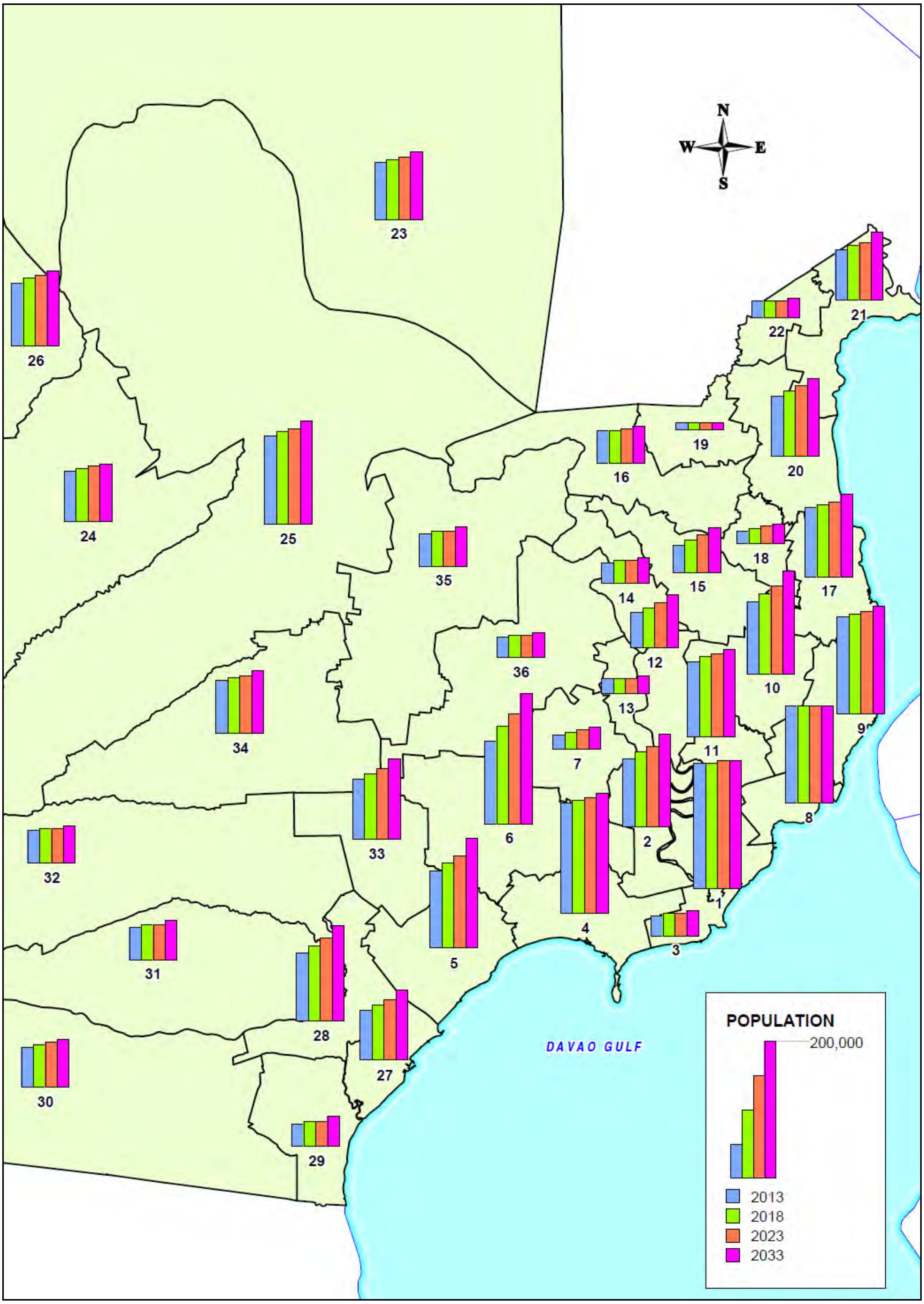
Central area in Davao City such as Poblacion and Agdao are already saturated, the annual growth rate is low. However, areas next to Buhangin, Talomo, Tugbok, and Toril have recently increased population showed ahigh growth rate.

Figure 6.2-5 shows the population by zone and **Figure 6.2-6** shows the population density. The projected population of each zone are all increasing.



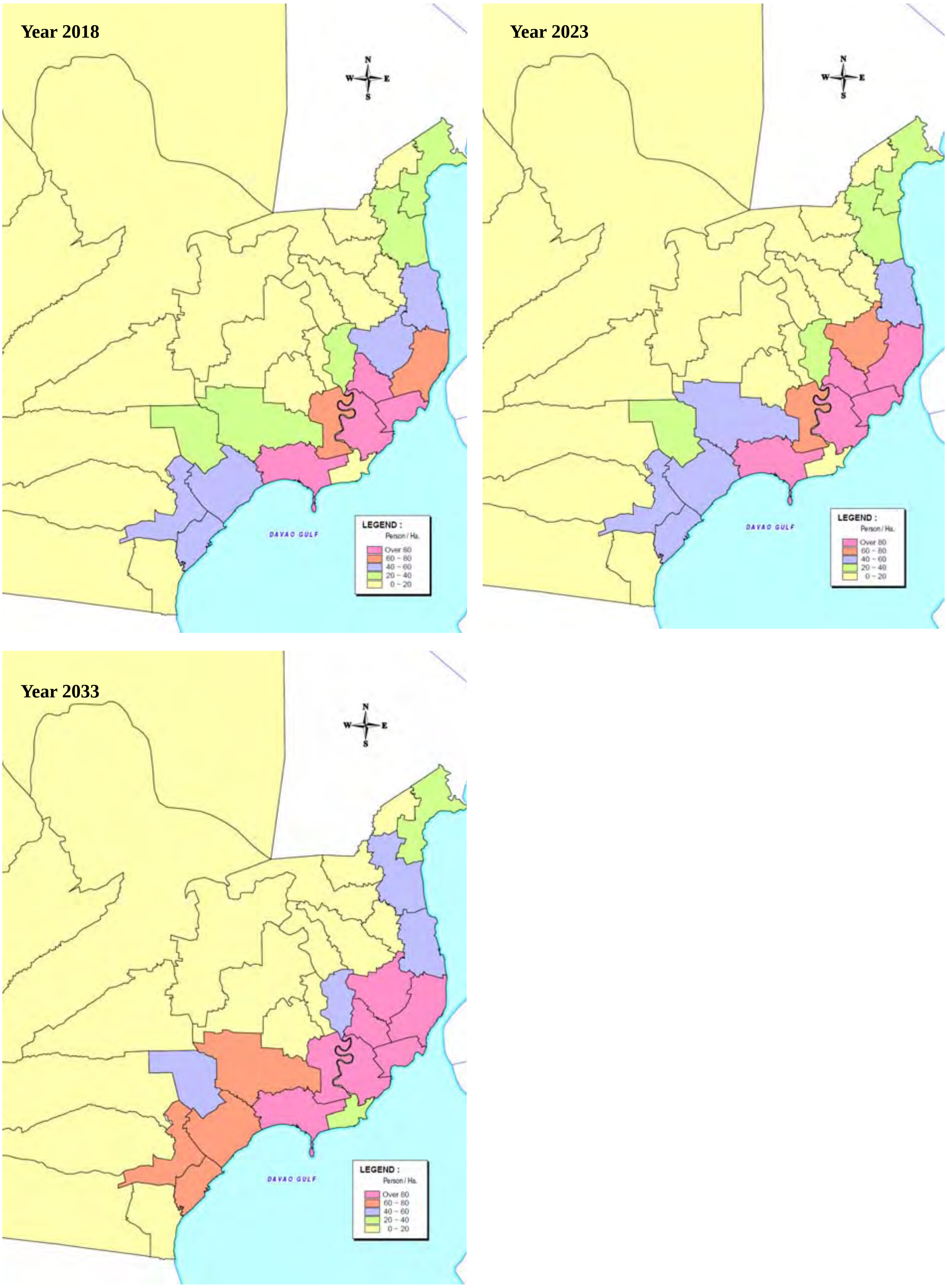
Source: JICA Study Team

FIGURE 6.2-4 ANNUAL GROWTH RATE OF POPULATION PROJECTION



Source: JICA Study Team

FIGURE 6.2-5 PROJECTED POPULATION IN THE STUDY AREA



Source: JICA Study Team

FIGURE 6.2-6 PROJECTED POPULATION DENSITY

TABLE 6.2-3 FUTURE POPULATION AND DENSITY IN THE STUDY AREA

Zone	Municipality	Land Area (Ha)	Year 2013		Year 2018		Year 2023		Year 2033	
			Population	Density (Persons/Ha)	Population	Density (Persons/Ha)	Population	Density (Persons/Ha)	Population	Density (Persons/Ha)
1	POBLACION	1,149.5	158,809	138	161,205	140	162,013	141	163,640	142
2	TALOMO	1,000.7	55,181	55	63,970	64	73,085	73	91,746	92
3		497.0	79,533	160	80,733	162	81,138	163	81,953	165
4		1,466.7	125,925	86	131,695	90	137,048	93	146,949	100
5		1,728.5	70,244	41	79,863	46	94,395	55	126,859	73
6		2,803.7	76,500	27	101,413	36	125,174	45	171,519	61
7		1,308.7	4,365	3	5,362	4	6,399	5	8,600	7
8	AGDAO	609.6	100,905	166	102,427	168	102,940	169	103,974	171
9	BUHANGIN	1,358.3	102,418	75	108,177	80	113,695	84	124,352	92
10		1,342.4	59,767	45	73,066	54	86,780	65	114,380	85
11		665.7	65,223	98	71,308	107	77,198	116	85,275	128
12		810.2	17,114	21	21,429	26	25,574	32	35,213	43
13		525.5	3,454	7	3,907	7	4,314	8	5,194	10
14		1,059.6	6,577	6	7,557	7	8,409	8	10,236	10
15		1,524.3	11,188	7	14,951	10	18,454	12	26,032	17
16		2,366.2	14,044	6	15,354	6	16,623	7	19,102	8
17	BUNAWAN	1,271.5	55,988	44	61,212	48	66,268	52	75,778	60
18		667.5	3,131	5	4,069	6	4,914	7	6,359	10
19		916.3	1,044	1	1,153	1	1,258	1	1,458	2
20		1,547.2	44,900	29	51,048	33	57,195	37	70,407	46
21		1,408.7	32,568	23	37,390	27	42,303	30	52,587	37
22		641.3	4,494	7	4,865	8	5,200	8	5,859	9
23	PAQUIBATO	65,630.7	41,881	1	45,340	1	48,604	1	54,762	1
24	BAGUIO	18,838.6	32,054	2	34,702	2	37,200	2	41,913	2
25	CALINAN	22,989.6	86,344	4	93,476	4	100,205	4	112,900	5
26	MARILOG	63,158.7	47,887	1	52,355	1	56,679	1	65,134	1
27	TORIL	773.5	32,747	42	38,893	50	45,088	58	58,282	75
28		1,359.8	54,676	40	64,938	48	75,281	55	97,311	72
29		1,509.0	7,721	5	9,038	6	10,176	7	12,650	8
30		10,946.5	21,729	2	23,874	2	25,846	2	29,701	3
31		5,701.8	15,272	3	16,779	3	18,165	3	20,874	4
32		9,486.3	14,840	2	16,304	2	17,651	2	20,284	2
33	TUGBOK	1,576.9	42,855	27	49,200	31	55,937	35	70,909	45
34		4,762.1	33,660	7	36,801	8	39,841	8	45,783	10
35		5,110.7	15,166	3	16,581	3	17,950	4	20,628	4
36		3,455.1	6,866	2	7,655	2	8,451	2	10,102	3
Total		241,968	1,547,069	1,190	1,708,090	1,295	1,867,452	1,396	2,188,702	1,601

Source: JICA Study Team

(2) Employment Projection

The employment at job site was selected as an index to reflect traffic generation/attraction. The number of projected employment is taken from the CLUP of Davao City, the growth rate is shown at a medium rate between population growth rate and GRDP growth rate.

Table 6.2-4 shows the projected employment by zone.

TABLE 6.2-4 PROJECTED POPULATION AND EMPLOYMENT BY ZONE

Zone	Municipality	Year 2013		Year 2018		Year 2023		Year 2033	
		Population	Employment	Population	Employment	Population	Employment	Population	Employment
1	POBLACION	158,809	207,713	161,205	229,332	162,013	247,055	163,640	281,118
2	TALOMO	55,181	22,315	63,970	29,165	73,085	35,654	91,746	52,272
3		79,533	44,271	80,733	48,401	81,138	52,399	81,953	60,215
4		125,925	47,947	131,695	58,334	137,048	68,119	146,949	92,440
5		70,244	21,360	79,863	27,067	94,395	33,650	126,859	51,020
6		76,500	22,887	101,413	31,283	125,174	39,736	171,519	60,829
7		4,365	2,200	5,362	2,405	6,399	2,604	8,600	2,992
8	AGDAO	100,905	44,593	102,427	48,753	102,940	52,780	103,974	60,653
9	BUHANGIN	102,418	58,853	108,177	64,343	113,695	69,658	124,352	80,048
10		59,767	12,931	73,066	14,137	86,780	15,305	114,380	17,587
11		65,223	2,090	71,308	2,285	77,198	2,473	85,275	2,842
12		17,114	2,284	21,429	2,498	25,574	2,704	35,213	3,107
13		3,454	2,025	3,907	2,214	4,314	2,396	5,194	2,754
14		6,577	7,131	7,557	9,083	8,409	10,961	10,236	15,829
15		11,188	2,339	14,951	3,210	18,454	4,077	26,032	6,332
16		14,044	2,356	15,354	2,929	16,623	3,487	19,102	4,895
17	BUNAWAN	55,988	46,602	61,212	50,950	66,268	55,159	75,778	63,386
18		3,131	2,258	4,069	3,056	4,914	3,840	6,359	5,714
19		1,044	2,253	1,153	2,814	1,258	3,363	1,458	4,742
20		44,900	20,003	51,048	25,348	57,195	30,692	70,407	44,565
21		32,568	14,957	37,390	19,043	42,303	23,169	52,587	33,805
22		4,494	2,195	4,865	2,716	5,200	3,213	5,859	4,468
23	PAQUIBATO	41,881	1,702	45,340	2,106	48,604	2,495	54,762	3,468
24	BAGUIO	32,054	1,983	34,702	2,454	37,200	2,907	41,913	4,042
25	CALINAN	86,344	2,124	93,476	2,628	100,205	3,114	112,900	4,329
26	MARILOG	47,887	2,054	52,355	2,553	56,679	3,040	65,134	4,267
27	TORIL	32,747	32,624	38,893	35,668	45,088	38,614	58,282	44,374
28		54,676	7,490	64,938	9,929	75,281	12,226	97,311	17,247
29		7,721	7,366	9,038	9,468	10,176	11,492	12,650	16,767
30		21,729	2,124	23,874	2,647	25,846	3,190	29,701	4,287
31		15,272	2,201	16,779	2,802	18,165	3,377	20,874	4,538
32		14,840	2,145	16,304	2,732	17,651	3,292	20,284	4,424
33	TUGBOK	42,855	2,281	49,200	2,904	55,937	3,542	70,909	5,218
34		33,660	2,275	36,801	2,828	39,841	3,367	45,783	4,726
35		15,166	1,999	16,581	2,485	17,950	2,958	20,628	4,153
36		6,866	2,051	7,655	2,574	8,451	3,094	10,102	4,429
Total		1,547,069	661,979	1,708,090	763,145	1,867,452	859,205	2,188,702	1,077,881

Source: JICA Study Team

(3) GDP Projection

The National Economic and Development Authority in the Philippines have not yet released the future GDP growth rate. Thus, the JICA Study Team based the growth rate of future GDP on future development of Davao City from the CLUP report and GDP growth rate of IMF, ADB, and WB in the Philippines (shown in **Table 6.2-5**). As the estimated result, GDP in Davao City is 6.00% from year 2013 to year 2018, 5.50% from year 2018 to 2023 and 5.50% from year 2023 to year 2033.

TABLE 6.2-5 ESTIMATED GDP GROWTH RATE ON EACH FINANCIAL INSTITUTION

Year	2012	2013	2014	2015	2016	2017	2018
IMF Estimated	6.59%	6.02%	5.47%	5.30%	5.40%	5.50%	5.50%
ADB Estimated	-	7.00%	6.10%	-	-	-	-
WB Estimated	-	7.50%	-	-	-	-	-

Source: IMF, ADB, World Bank

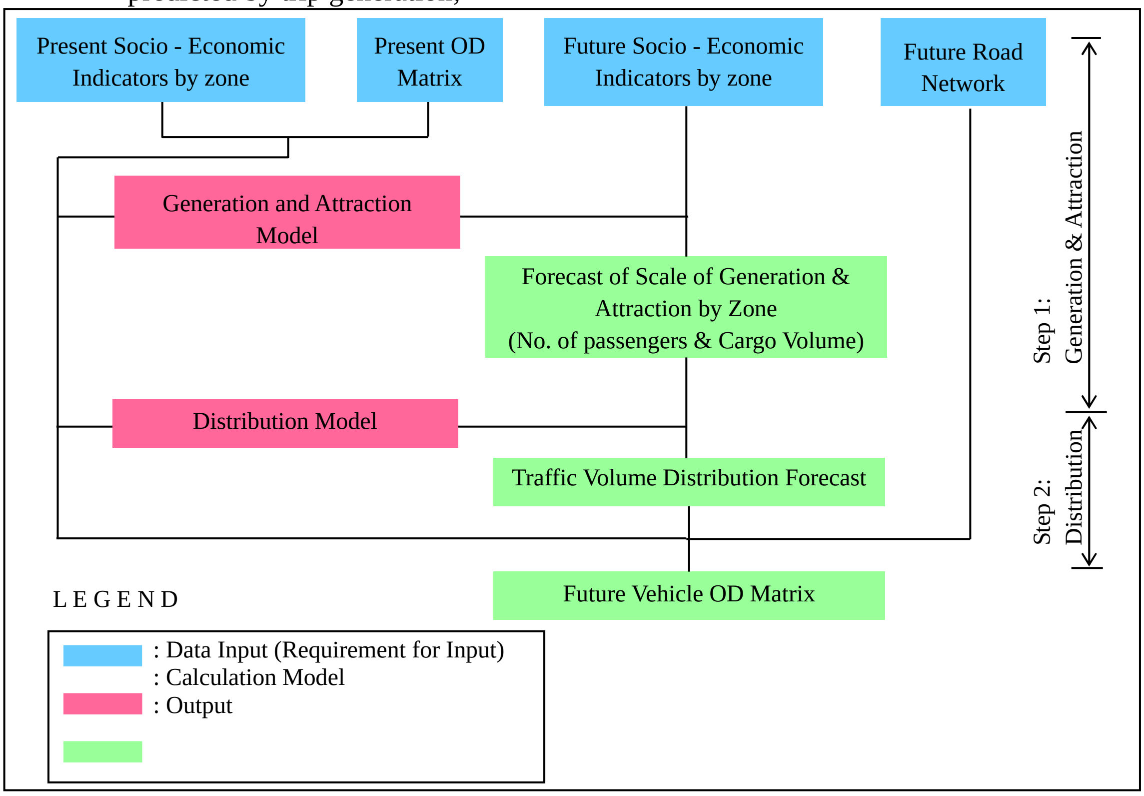
6.2.3 Present and Future OD Matrix

The Present OD matrix was prepared based on the 2009 OD matrix of HSH and revised and updated for Year 2013 taken from the roadside OD interview survey result. The ttraffic assignment model was validated using this present OD matrix (see 6.2.5 Assignment Validation). In order to formulate the future OD table, traffic demand forecast was conducted by applying the revised future socio-economic indicators by zone.

(1) Future OD Estimation Approach

The future OD Matrix was prepared by the following as shown in **Figure 6.2-7**.

- Trip Generation and Attraction – the prediction of trips produced and attracted to each zone;
- Model Growth Method – the growth rate of existing reproduced demand and future reproduced demand to OD pair;
- Trip Distribution – the prediction of origin-destination flows, the linking of trip ends predicted by trip generation;



Source: JICA Study Team

FIGURE 6.2-7 CONCEPT OF TRANSPORTATION MODELING IN THE STUDY

(2) Modeling and Forecasting Tools

During traffic demand forecasting, JICA STRADA system and EXCEL spreadsheet were employed. JICASTRADA is a geographic information system designed specifically for planning, managing, and analyzing of transportation systems. The software provides a set of tools for travel demand modeling as well as capabilities for geographic database management, presentation graphics and transportation models. JICASTRADA system is applied for simulation of travel time and cost. For better precision, efficiency and minimization of trial errors, model calibrations and forecasts in trip generation, trip distribution and modal split steps are programmed using Excel spreadsheet, and the final step, traffic assignment stage is computed by JICA STRADA system.

(3) Traffic Demand Forecast Modeling

1) Trip Generation and Attraction Model

The objective of trip generation and attraction model is to forecast the number of trips by vehicle type that will depart and arrive in each traffic zone within the Davao City area. The linear regression models were adopted. The model parameters were calibrated as shown in **Table 6.2-6**.

Figure 6.2-8 shows the verification results between observed (present OD trips) and estimated trips for each vehicle type trips, and **Figure 6.2-11** shows the estimated desire line of each vehicle trips.

$$Gi = ai * X1i + bi * X2i$$

$$Aj = aj * X1j + bj * X2j$$

Where,

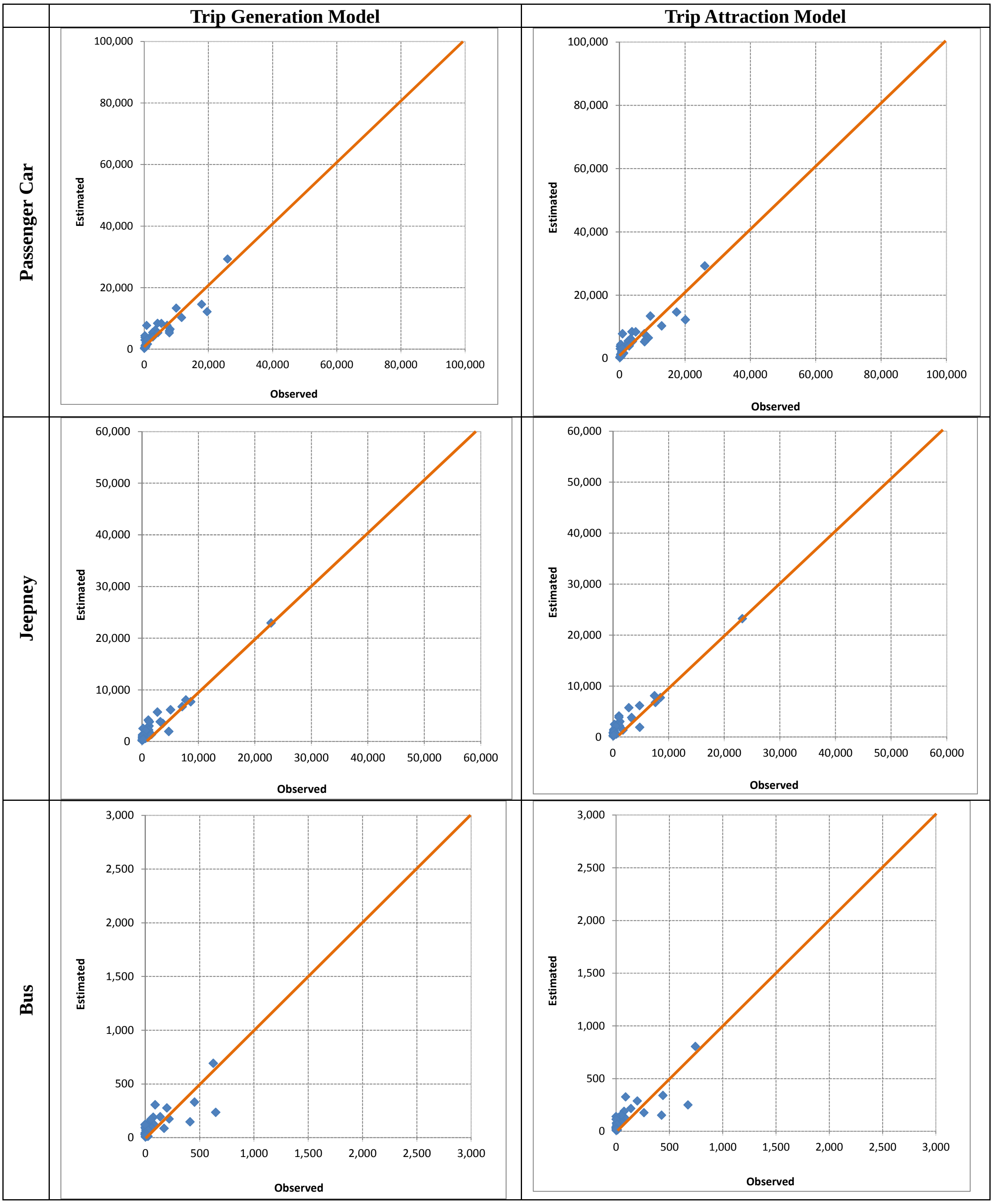
Gi – Trip Generation in zone i $X1i$, $X2j$ – Attributes in zone i,j

Aj – Trip Attraction in zone j ai, aj, bi,bj – Coefficients

TABLE 6.2-6 GENERATION/ATTRACTION MODELS BY VEHICLE TYPE

Model Type	Vehicle Type	Population	Employment	R2 Multiple Correlation Coefficient
Trip Generation	Car	0.0876	0.0740	0.837
	Jeepney	0.0270	0.0898	0.935
	Bus	0.0019	0.0019	0.700
Trip Attraction	Car	0.0881	0.0732	0.822
	Jeepney	0.0265	0.0916	0.932
	Bus	0.0017	0.0026	0.753

Source: JICA Study Team

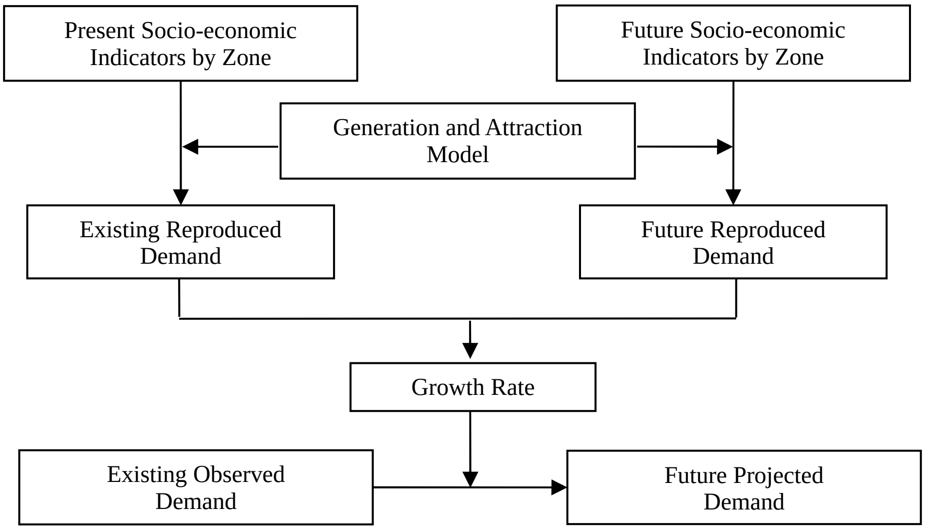


Source: JICA Study Team

FIGURE 6.2-8 VERIFICATION OF TRIP GENERATION AND ATTRACTION MODEL

2) Model Growth Method

The transport demand obtained from the transport survey covers inter Davao City trip and reproduced by observed traffic flows. The transport models are built by utilizing that demand data without intra-municipality demand, this causes much errors in the process of developing the models. In order to avoid the model error and bias from the demand forecasting, the Model Growth method (shown in **Figure 6.2-9**) was applied in the study.

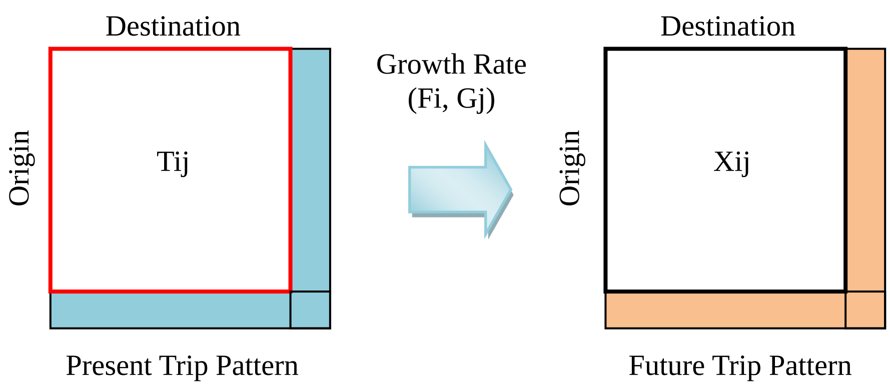


Source: JICA Study Team

FIGURE 6.2-9 CONCEPT OF MODEL GROWTH METHOD

3) Trip Distribution Model

Comparing the present and future road network, the future road network is almost the same as the present road network. Therefore, present trip pattern will not change on the future road network. In this case, trip distribution assumed that future trip pattern was estimated by multiplying growth rate to present trip pattern in the method of "Present Pattern Method" (shown in **Figure 6.2-10**). The truck trips was estimated by using this method.



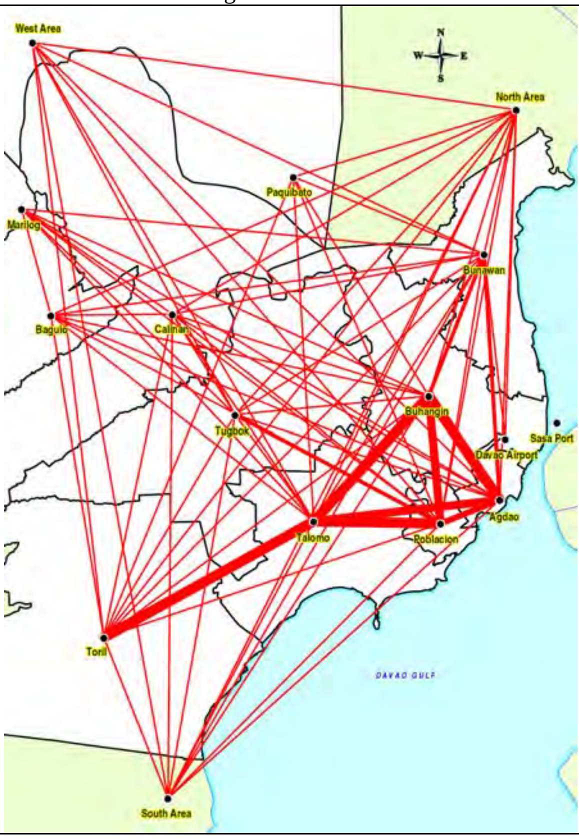
Source: JICA Study Team

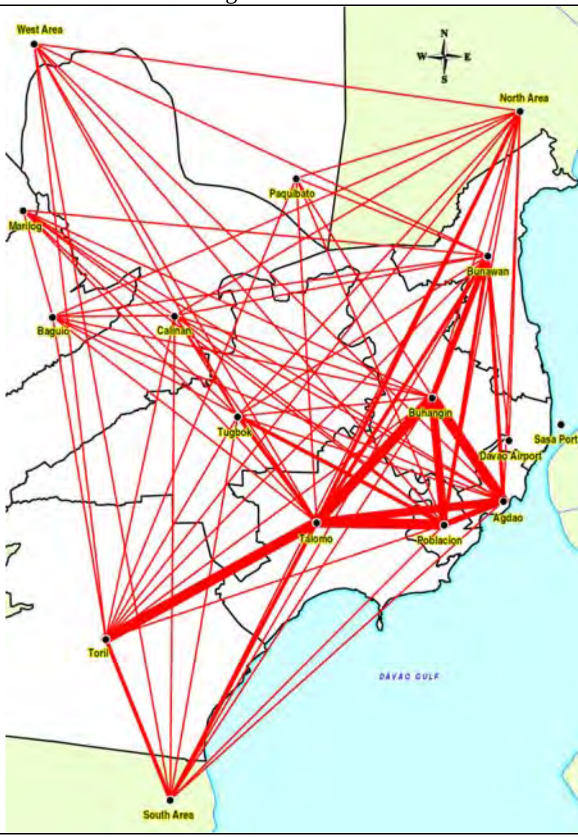
FIGURE 6.2-10 PRESENT PATTERN METHOD

4) Desire Lines

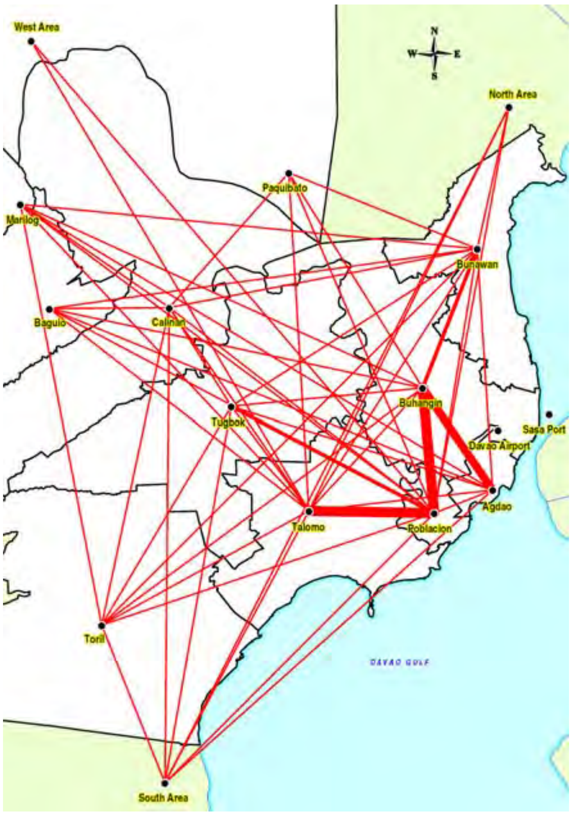
Desire lines for Passenger Car, Jeepney and Truck are illustrated in **Figure 6.2-11**.

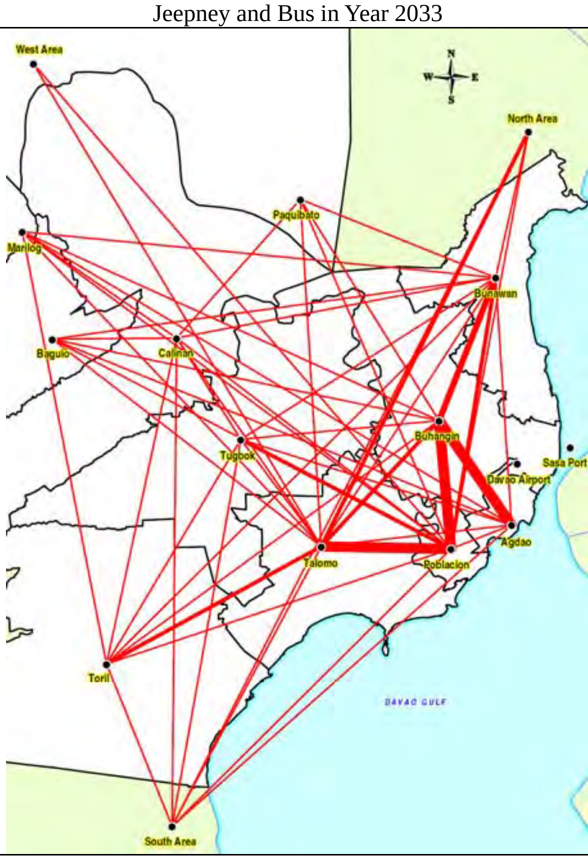
Passenger Car in Year 2013	Passenger Car in Year 2033



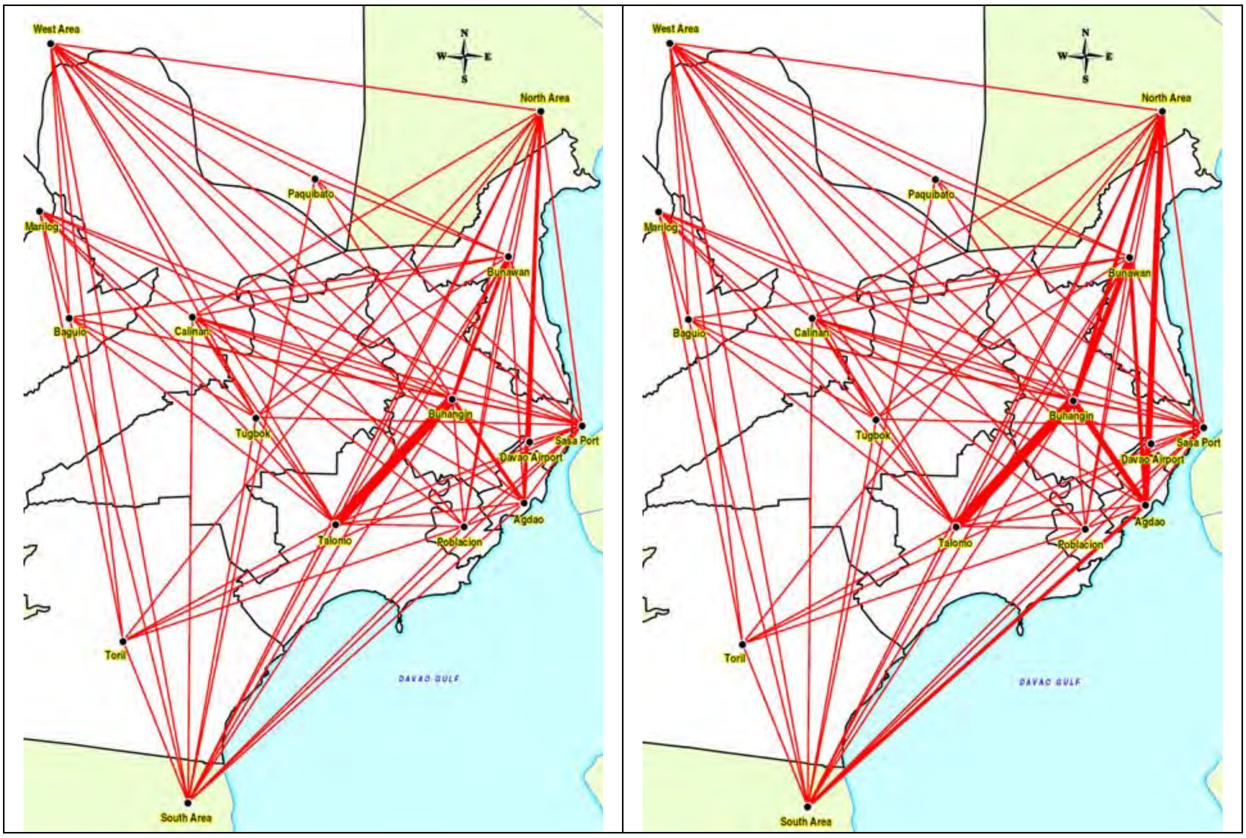


Jeepney and Bus in Year 2013	Jeepney and Bus in Year 2033





Truck in Year 2013	Truck in Year 2033



Source: JICA Study Team

FIGURE 6.2-11 DESIRE LINE

Estimated traffic generated by the Bypass project in the urban and sub-urban center of Davao City is shown in **Table 6.2-7** below.

TABLE 6.2-7 ESTIMATED TRAFFIC GENERATION

Zone		Year 2013					Year 2018					Year 2023					Year 2033				
		Car	Jeepney	Bus	Truck	Total	Car	Jeepney	Bus	Truck	Total	Car	Jeepney	Bus	Truck	Total	Car	Jeepney	Bus	Truck	Total
Davao City (urban)	(veh/day)	105,633	61,131	2,564	14,786	184,114	115,311	67,391	3,599	17,116	203,417	122,548	72,879	3,861	19,137	218,425	137,724	84,324	4,503	22,013	248,564
	(%)	-	-	-	-	-	1.8%	2.0%	7.0%	3.0%		1.2%	1.6%	1.4%	2.3%		2.4%	3.0%	3.1%	2.8%	
Davao City (sub-urban)	(veh/day)	45,738	17,717	867	7,486	71,808	58,952	22,239	1,103	8,682	90,976	67,880	25,810	1,303	9,717	104,710	87,592	34,151	1,732	11,144	134,619
	(%)	-	-	-	-	-	5.2%	4.7%	4.9%	3.0%		2.9%	3.0%	3.4%	2.3%		5.2%	5.8%	5.9%	2.8%	
Total		255,922					294,393					323,135					383,183				
Increase from 2013		-					1.15					1.26					1.50				

Source: JICA Study Team

From the traffic baseline of 2013, the estimated increase of traffic generated in 2018 is an increase of 0.15%, 0.26% in 2023 and 0.50% in 2033. The Davao City Urban Center is comprised of traffic zoning 1, 2, 3, 4, 8, 9, 10 and 11.

6.2.4 Traffic Assignment Model

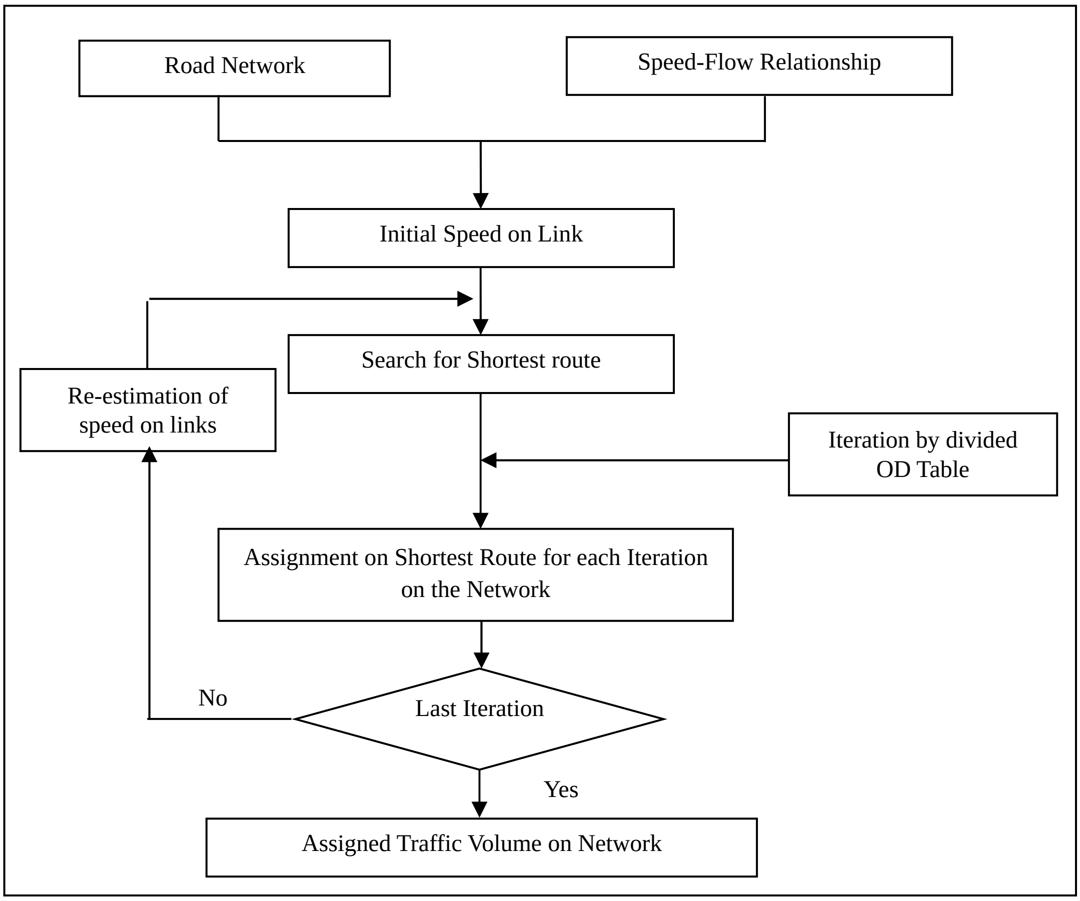
The traffic assignment procedure allocates the vehicle traffic into the individual road links. This step uses as input for the matrix of flows (vehicles) that indicate the volume of traffic between origin and destination pairs.

(1) Assignment Method

There are so many assignment techniques that can be used to estimate the traffic volume ranging from manual methods to complex iterative procedures by using computer programs. In this study, the capacity restraint assignment which is the most straightforward to use in network models was applied. This assignment technique is based on the speed – flow relationship. The flow chart of the applied methodology is presented in **Figure 6.2-12**.

In this assignment technique, the program determines the fastest routes between each origin and destination by evaluating the time utilized on each links by calculating the required travel time for each link according to its travel speed and road conditions, and then assigns the trips between the given origin and destination. As congestion increases until a certain level, alternative routes are introduced to handle the unassigned traffic. Zone-to-zone routing is built, which is the fastest path from each zone to another, and all trips are assigned to these optimum routes.

Since the link-travel time varies with the traffic volume of vehicles using that link, the OD tables are divided to apply an iteration procedure on five (5) stages, this can be explained as a degree of link congestionAt each iteration, and depending on the current link loadings, the flows are divided between all the shortest routes generated and a new travel time is computed for the average assigned link flow at each pass. The iteration continues to re-estimate the speed on that links considering the assigned traffic on links, and to produce the alternative routes so that more accurate allocation can be achieved. The accumulated assigned traffic volume from each OD pair on the links composes the total assigned traffic volumes per direction for the network. JICA STRADA is used to estimate traffic volumes.

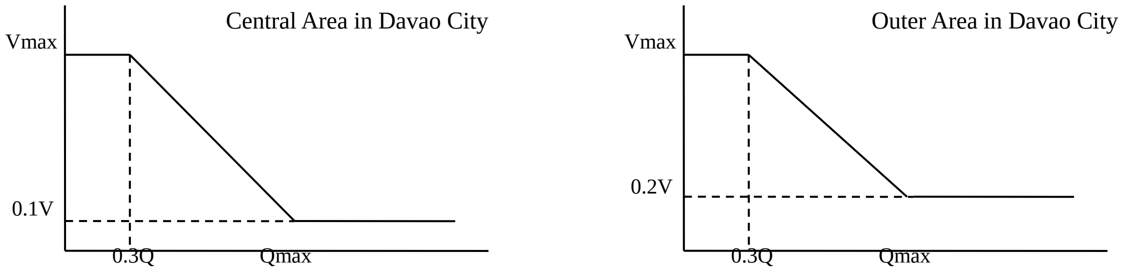


Source: JICA Study Team

FIGURE 6.2-12 TRAFFIC ASSIGNMENT PROCEDURE

(2) Speed-Flow Relationship

The speed-flow relationship used in the traffic assignment procedure is shown in **Figure 6.2-13** Speed – Flow Relationship. When the traffic volumes are over the maximum capacity 0.3*Q*max*, it is assumed that vehicle speed drastically reduces. These speed-flow relationships are classified for the central area and for the outer area in Davao City. The basic free flow and capacity is shown in **Table 6.2-8**.



Source: JICA Study Team

FIGURE 6.2-13 SPEED – FLOW RELATIONSHIP

TABLE 6.2-8 FREE SPEED AND CAPACITY BY ROAD TYPE

<table>
<tr><th>QV Type</th><th>Pavement</th><th>Road Class</th><th>Topography</th><th>Lane</th><th>Vmax</th><th>Qmax</th></tr>
<tr><td>1</td><td rowspan="10">Paved</td><td rowspan="5">Urban Arterial</td><td rowspan="3">Plain</td><td>6</td><td>50</td><td>72,000</td></tr>
<tr><td>2</td><td>4</td><td>40</td><td>48,000</td></tr>
<tr><td>3</td><td>2</td><td>30</td><td>24,000</td></tr>
<tr><td>4</td><td rowspan="2">Mountains</td><td>4</td><td>30</td><td>36,000</td></tr>
<tr><td>5</td><td>2</td><td>25</td><td>18,000</td></tr>
<tr><td>6</td><td rowspan="5">Local</td><td rowspan="3">Plain</td><td>4</td><td>40</td><td>40,000</td></tr>
<tr><td>7</td><td>2</td><td>30</td><td>12,000</td></tr>
<tr><td>8</td><td>1</td><td>30</td><td>7,000</td></tr>
<tr><td>9</td><td rowspan="2">Mountains</td><td>2</td><td>30</td><td>8,400</td></tr>
<tr><td>10</td><td>1</td><td>20</td><td>6,000</td></tr>
<tr><td>11</td><td rowspan="2">Unpaved</td><td rowspan="2"></td><td>Plain</td><td>2</td><td>20</td><td>6,000</td></tr>
<tr><td>12</td><td>Mountains</td><td>3</td><td>10</td><td>4,200</td></tr>
</table>

Source: JICA Study Team

(3) Passenger Car Unit

Table 6.2-9 shows the Passenger Car Unit (PCU) used in vehicle traffic conversion. This value is the same used by the DPWH.

TABLE 6.2-9 PASSENGER CAR UNIT (PCU)

Vehicle Type	Passenger Car Unit
Passenger Car	1.0
Jeepney	1.5
Bus	2.0
Truck	2.5

Source: DPWH

6.2.5 Assignment Validation

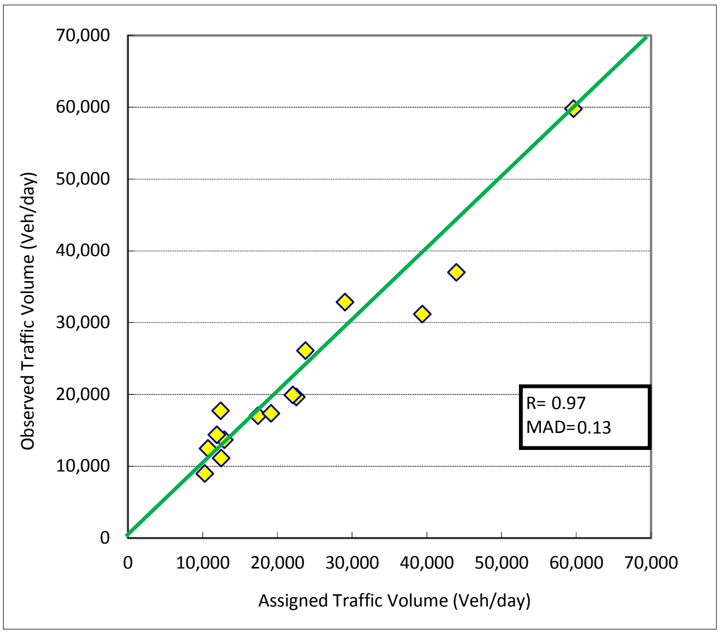
The procedure of model validation entails two steps. First, the present OD matrix is assigned on an existing network. Second, the assigned traffic volume is compared with the result of the traffic count surveys at each corresponding location. This verification aims to check the accuracy of both the current OD matrix and an existing network model which represents the existing transport situation.

Table 6.2-10 presents the traffic volumes generated from traffic assignment volume and observed traffic volume (traffic count survey). **Figure 6.2-14** shows the result of comparison between the assigned traffic volume and observed traffic volume. This comparison between observed traffic count and assigned traffic flow at individual sites is done via the Correlation and the Mean Absolute Difference (MAD) Ratio. For daily traffic counts, the correlation is 0.97, the value of the MAD ratio is 0.12 which is considered to reflect a good calibration. By all indicators the assignment was accurately replicated by year 2013.

TABLE 6.2-10 COMPARISON OF OBSERVED (SURVEY DATA) AND ASSIGNED TRAFFIC VOLUME

No	Station	Observed Traffic Volume	Assigned Traffic Volume	Difference	Rate
1	MacArthur Highway (South of Apo Golf & Country Club)	26,050	23,752	2,298	10%
2	MacArthur Highway (Toril)	11,066	12,480	-1,414	-11%
3	Davao-Bukidnon Rd. (North of MacArthur Highway)	16,965	17,406	-441	-3%
4	Davao-Bukidnon Rd. (Bet. Mintal and Tugbok)	8,940	10,310	-1,370	-13%
5	MacArthur Highway (East of Catalunan Grande Rd.)	36,969	43,978	-7,009	-16%
6	Pan Philippine Highway (Lasang)	13,623	12,927	696	5%
7	CP Garcia (East of Catalunan Grande Rd.)	14,344	11,914	2,430	20%
8	Bolton Bridge	32,821	29,063	3,758	13%
9	Bankerohan Bridge	59,724	59,635	89	0%
10	CP Garcia (East of Ma-a Rd.)	19,569	22,567	-2,998	-13%
11	Dacudao Ave. (Bet. CP Garcia and JP Laurel)	31,121	39,389	-8,268	-21%
12	Cabantian Rd. (North of CP Garcia)	12,433	10,732	1,701	16%
13	CP Garcia (West of Pan Philippine Highway)	19,847	22,073	-2,226	-10%
14	Pan Philippine Highway (South of CP Garcia))	17,683	12,417	5,266	42%
15	Pan Philippine Highway (Tibungco)	17,293	19,146	-1,853	-10%
Total		**338,448**	**347,789**	**-9,341**	**-3%**

Source: JICA Study Team



Source: JICA Study Team

FIGURE 6.2-14 COMPARED OBSERVED AND ASSIGNED TRAFFIC VOLUME

6.2.6 Traffic Assignment Result

Traffic assignment case is shown below;

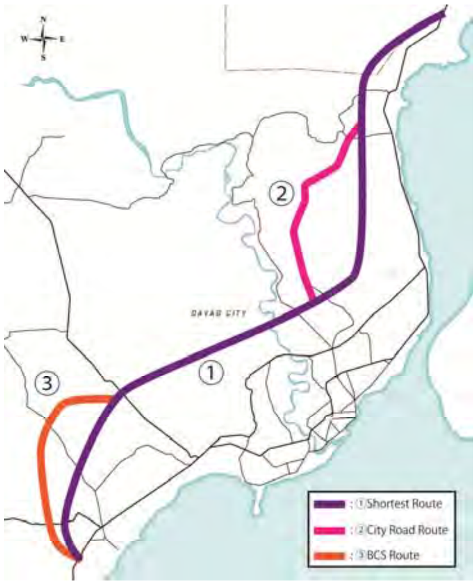
1. Alternative Route of Alignment: 4 cases (Base on Year 2013)
2. Alternative Route of Tunnel Section: 4 cases (Base on Year 2013)
3. Davao Bypass Construction Case: Year 2018, Year 2023, Year 2033

(1) Alternative Routes of Alignment

In order to come up with the most optimum route alignment, the team conducted several alternative studies as discussed in Chapter 9.

Several Cases were run-through and evaluated. Alternative routes of alignment case is shown below and in **Figure 6.2-15**.

- Case-1: Shortest Route (No.1)
- Case-2: Shortest Route and City Road Route (No1 and No.2)
- Case-3: Shortest Route and BCS Route (No.1 and No. 3)
- Case-4: City Road Route and BCS Route (No. 2 and No.3,)



Source: JICA Study Team

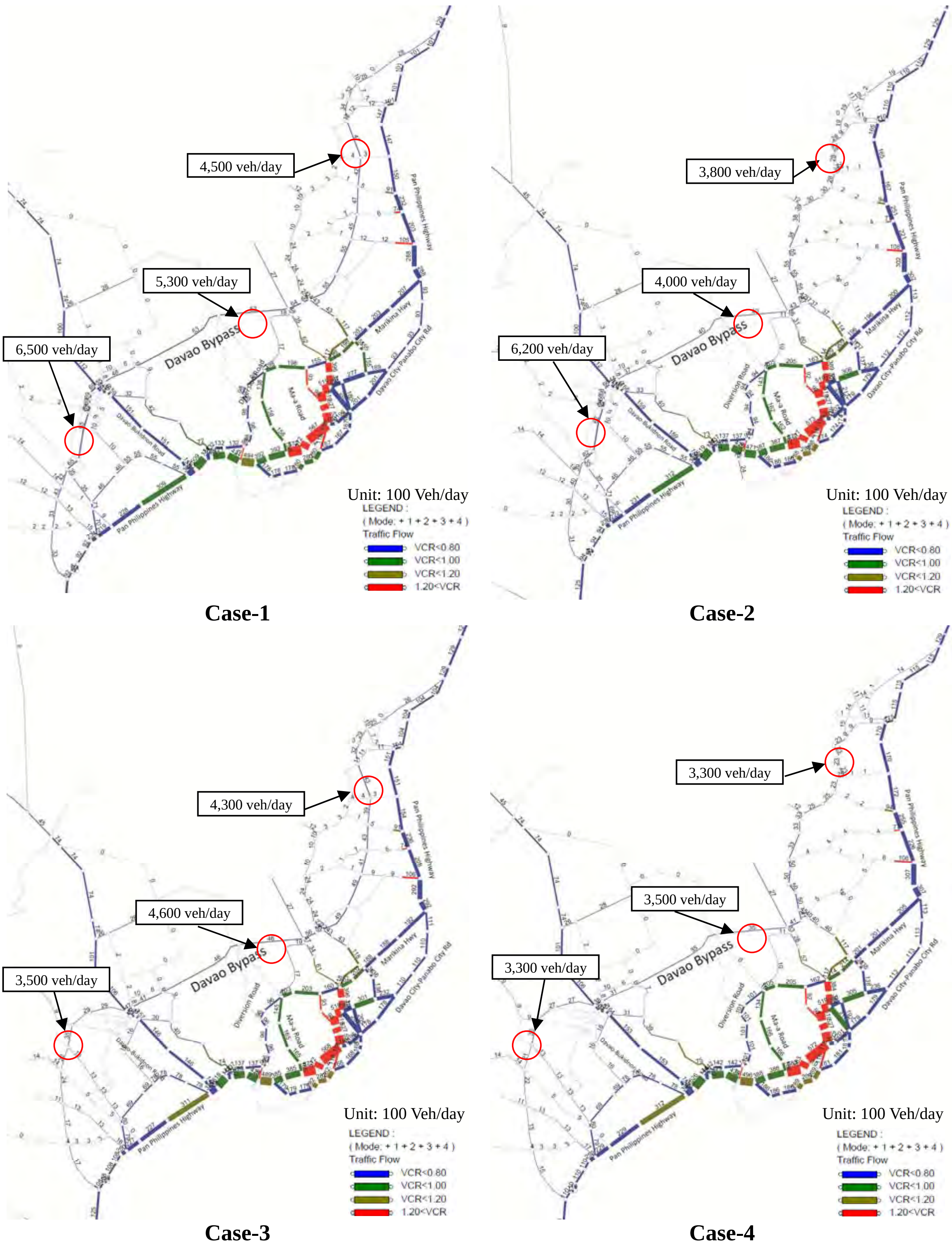
FIGURE 6.2-15 ALTERNATIVE ROUTE

These cases were estimated using JICA STRADA as shown in **Figure 6.2-16**. The traffic indicators such as total vehicle-time (veh*hour/day), total vehicle-km (veh*km/day) and average speed are calculated within each cases comparing with a Do Nothing Case. As a result of comparing these cases, case-1 is with the most saved total vehicle-time and average speed, and case-3 is with the most saved total vehicle-km. However, traffic volume which is shifted from ordinary road is higher for alternative-1 than case-2. Totally, case-1 is a contributory route for Davao City.

TABLE 6.2-11 TRAFFIC INDICATOR OF WITH DAVAO BYPASS AND DO-NOTHING CASE ON YEAR 2013

Traffic Indicators		Case-1	Case-2	Case-3	Case-4
Total Vehicle Time (veh*hr/day)	With (W)	143,228	144,488	144,610	146,248
	Without (WO)	149,813	149,813	149,813	149,813
	Difference (WO-W)	6,585	5,325	5,203	3,565
Total Vehicle Km (veh*km/day)	With (W)	4,339,010	4,344,891	4,330,059	4,341,441
	Without (WO)	4,351,359	4,351,359	4,351,359	4,351,359
	Difference (WO-W)	12,349	6,468	21,300	9,918
Average Speed (km/h)	With (W)	30.3	30.1	30.0	29.8
	Without (WO)	29.0	29.0	29.0	29.0
	Difference (WO-W)	-1.3	-1.1	-1.0	-0.8
Average Traffic Volume (veh /day)	North Section	4,271	3,851	3,146	2,688
	Tunnel Section	5,321	4,012	4,606	3,485
	South Section	4,986	4,541	2,676	2,359

Source: JICA Study Team



Source: JICA Study Team

FIGURE 6.2-16 RESULT OF ALL ALTERNATIVE TRAFFIC VOLUME ON ALIGNMENTS BASE YEAR 2013

TABLE 6.2-12 ALTERNATIVE ROUTE FOR EACH CASE

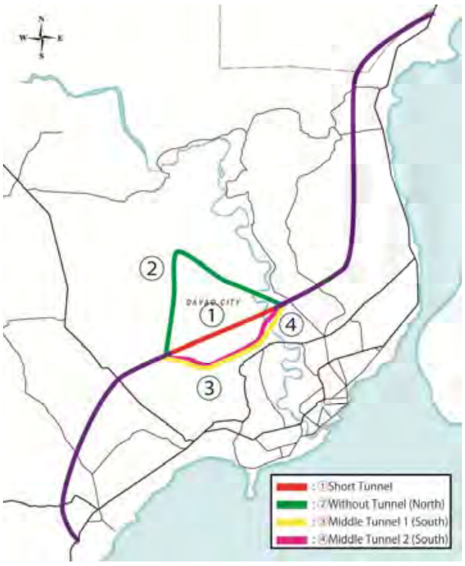
	Alternative Route (see Figure 9.6-6)		
	North Section	Center Section	South Section
Case-1	N-2A N-2B	Alignment 3 ~ 6	S-2A S-2B
Case-2	N-3	Alignment 3 ~ 6	S-2A S-2B
Case-3	N-2A N-2B	Alignment 3 ~ 6	S-1
Case-4	N-3	Alignment 3 ~ 6	S-1

(2) Alternative Routes of Tunnel Section

Alternative routes of tunnel section case is shown below and in **Figure 6.2-17**.

As forecasted, the traffic volume was estimated by using JICA STRADA, Case-1 is 5,321 veh/day, Case-2 is 1,619 veh/day, Case-3 is 3,490 veh/day, Case-4 is 3,623 veh/day. Case-1 is with the highest volume of all cases.

And, comparing all these cases regarding traffic indicators, Case-1 is with the most saved total vehicle-time, total vehicle-km and average speed. Therefore, Case-1 is the recommended main route for the future network.



Source: JICA Study Team

FIGURE 6.2-17 TUNNEL ROUTE

TABLE 6.2-13 TRAFFIC INDICATOR OF WITH DAVAO BYPASS AND DO-NOTHING CASE ON YEAR 2013

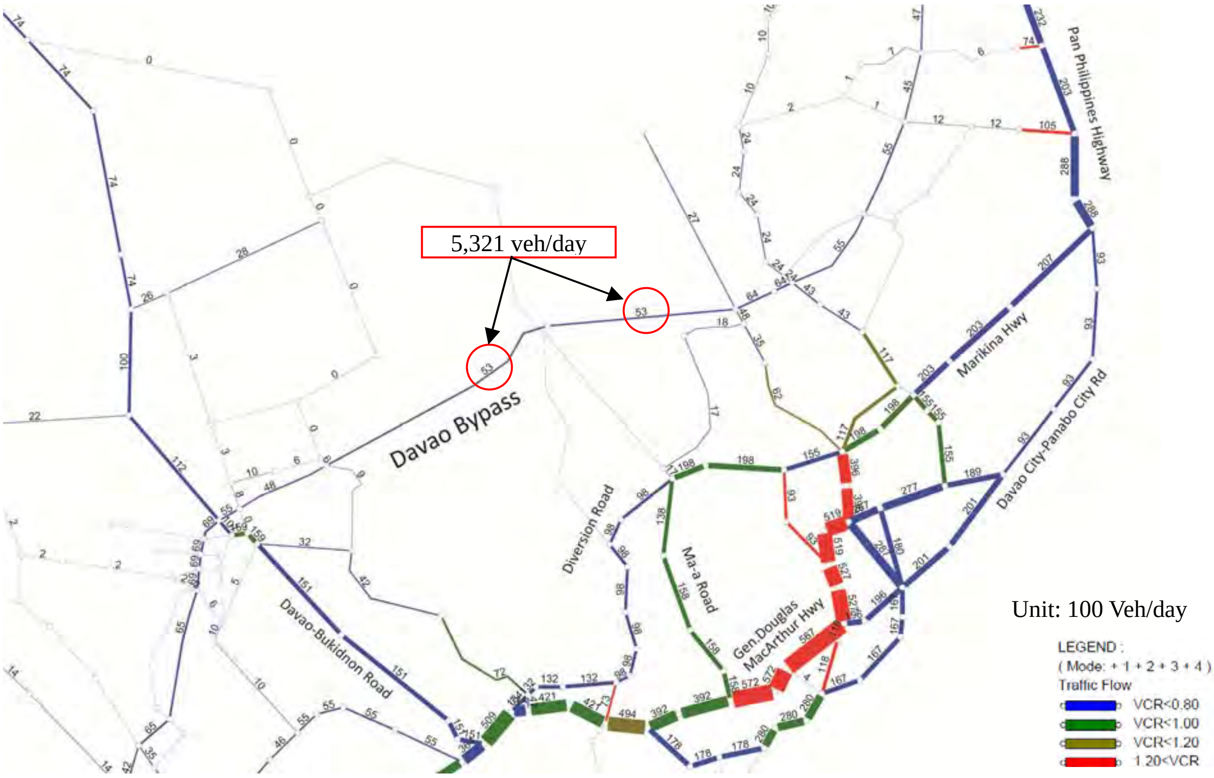
Traffic Indicators		Case-1	Case-2	Case-3	Case-4
Total Vehicle Time (veh*hr/day)	With (W)	143,228	146,619	144,383	144,254
	Without (WO)	149,813	149,813	149,813	149,813
	Difference (WO-W)	6,585	3,194	5,430	5,559
Total Vehicle Km (veh*km/day)	With (W)	4,339,010	4,388,330	4,357,271	4,354,971
	Without (WO)	4,351,359	4,351,359	4,351,359	4,351,359
	Difference (WO-W)	12,349	-36,971	-5,912	-3,612
Average Speed (km/h)	With (W)	30.3	29.9	30.2	30.2
	Without (WO)	29.0	29.0	29.0	29.0
	Difference (WO-W)	-1.3	-0.9	-1.2	-1.2
Average Traffic Volume (veh/day)		5,321	1,619	3,490	3,623

Source: JICA Study Team

TABLE 6.2-14 ALTERNATIVE ROUTE FOR TUNNEL SECTION

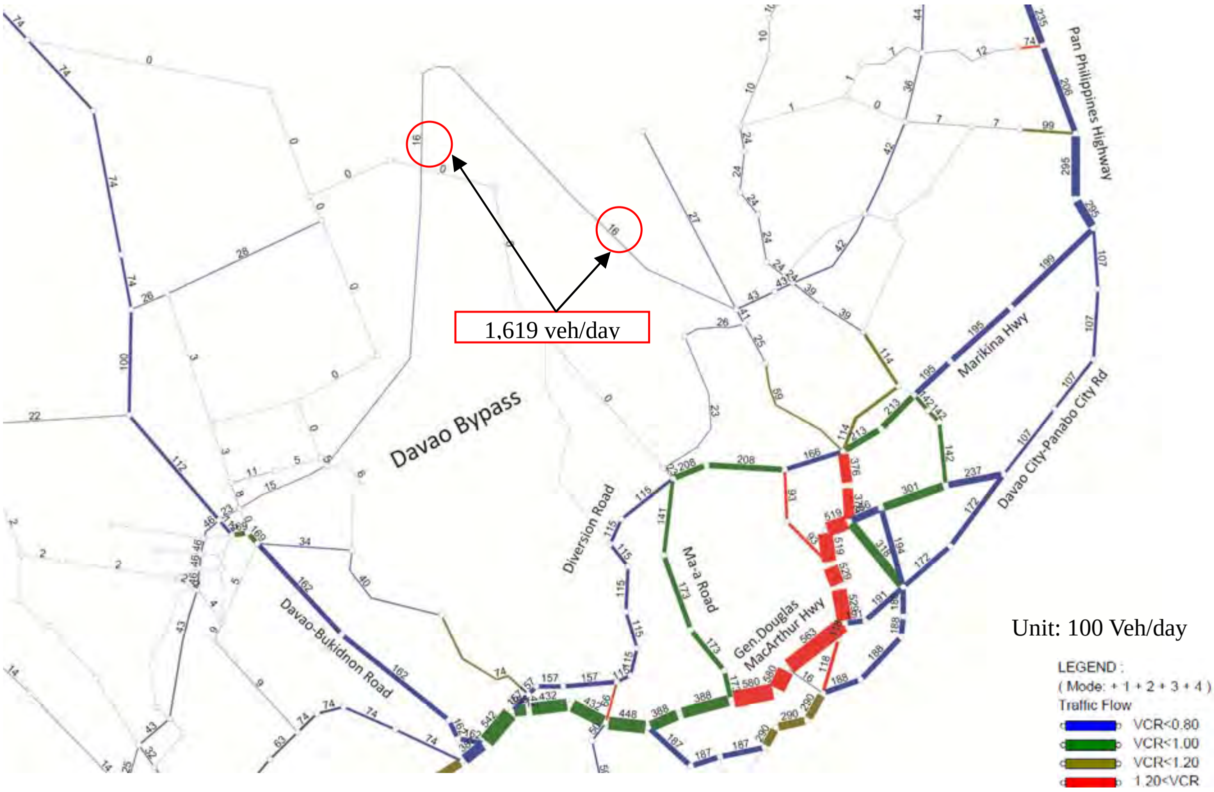
	Route	Alternative for Center Section (see **Figure 9.6-4**)
Case-1	Shortest Route , l = 9.80km (Tunnel length 2.20 ~ 2.90 km)	Alignment 3~6
Case-2	Route which does not require a tunnel, l = 18.60 km	Alignment 7
Case-3	Reduce tunnel length, l = 12.0 km (Tunnel length 1.45km)	Alignment 1
Case-4	Reduce tunnel length, l = 11.4 km (Tunnel length 1.60km)	Alignment 2

Source: JICA Study Team



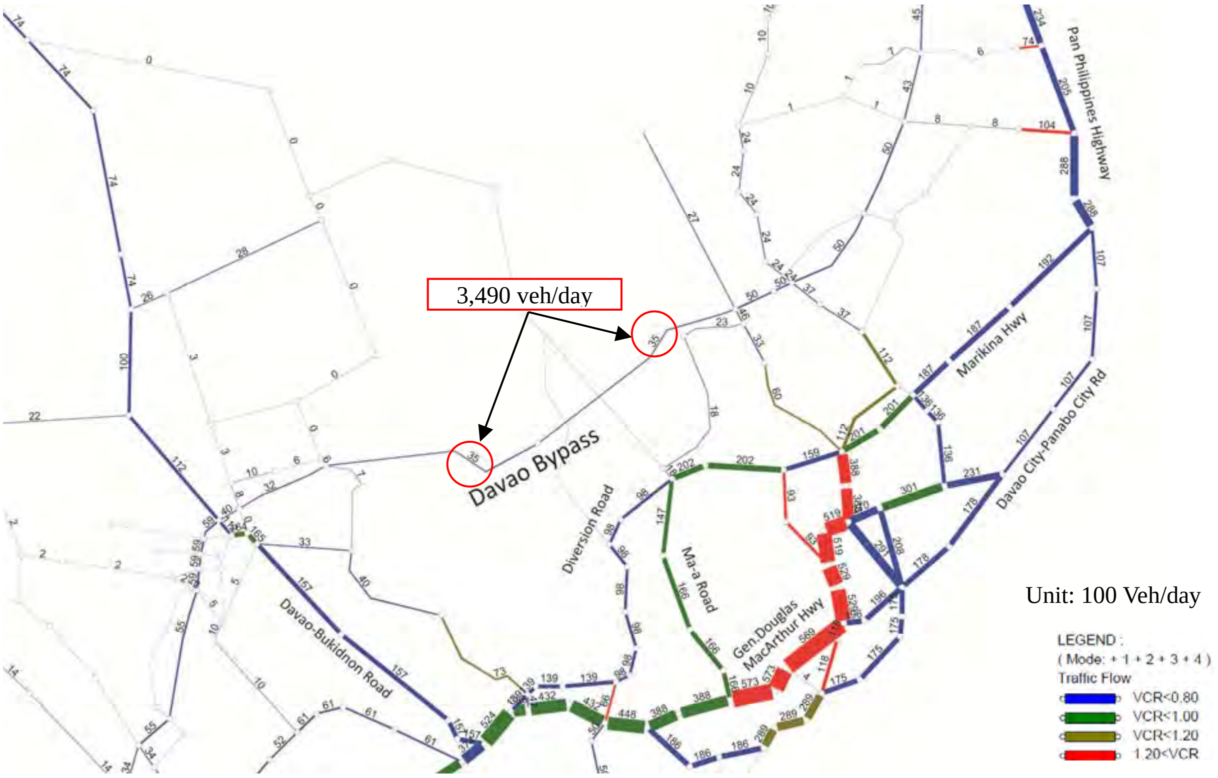
5,321 veh/day
Davao Bypass
Pan Philippines Highway
Marikina Hwy
Davao City-Panabo City Rd
Diversion Road
Ma-a Road
Gen.Douglas MacArthur Hwy
Davao-Bukidnon Road
Unit: 100 Veh/day
LEGEND :
(Mode: + 1 + 2 + 3 + 4)
Traffic Flow
VCR<0.80
VCR<1.00
VCR<1.20
1.20<VCR

Case-1

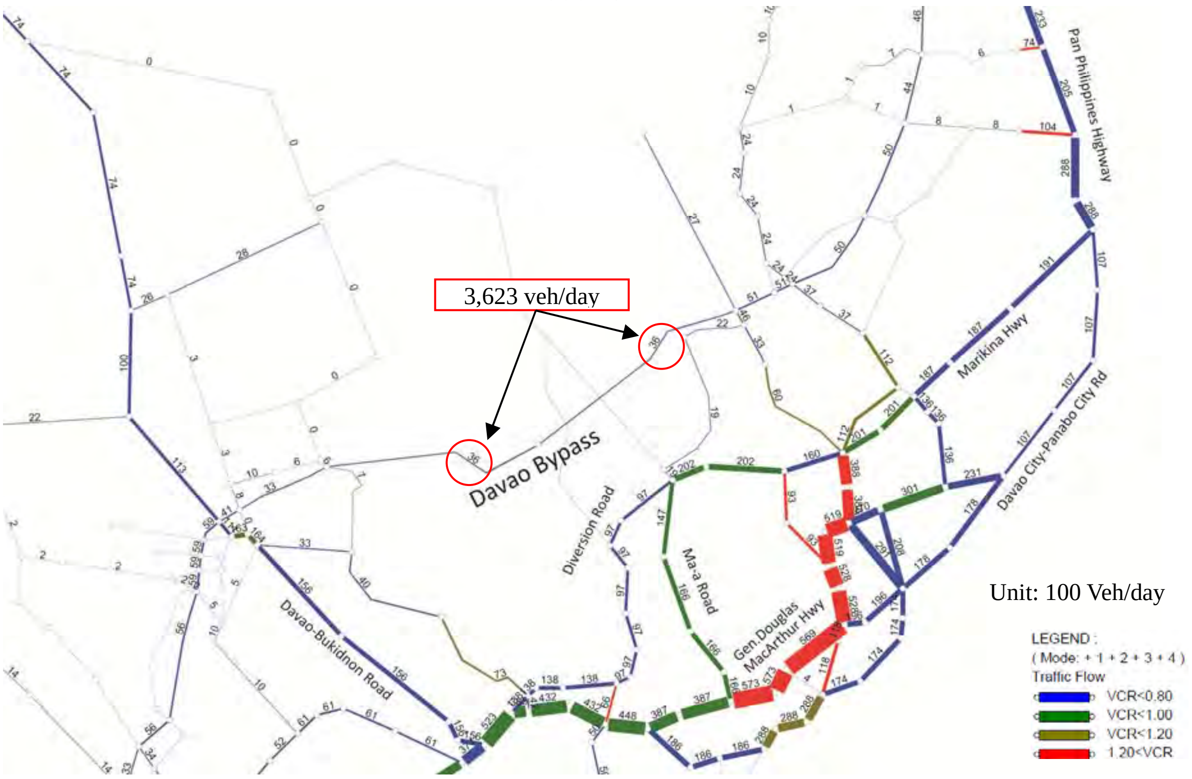


1,619 veh/day
Davao Bypass
Pan Philippines Highway
Marikina Hwy
Davao City-Panabo City Rd
Diversion Road
Ma-a Road
Gen.Douglas MacArthur Hwy
Davao-Bukidnon Road
Unit: 100 Veh/day
LEGEND :
(Mode: + 1 + 2 + 3 + 4)
Traffic Flow
VCR<0.80
VCR<1.00
VCR<1.20
1.20<VCR

Case-2



Case-3



Case-4

Source: JICA Study Team

FIGURE 6.2-18 RESULT OF ALL ALTERNATIVE TRAFFIC VOLUME ON TUNNEL SECTION BASE YEAR 2013

(3) Davao Bypass Construction Case: Year 2018, Year 2023, Year 2033

The future traffic demand was estimated based on the results of alternative alignment and tunnel section as shown in **Figure 6.2-19** to **Figure 6.2-21.** Traffic indicators were calculated in years

2018, 2023 and 2033 as shown in **Table 6.2-15.**

- Total vehicle time saved in each year are 13,829 veh*hr/day, 18,617 veh*hr/day, 22,622 veh*hr/day respectively.

- Total vehicle-km saved in each year are 12,349 veh*km/day, -55,980 veh*km/day, -110,222 veh*km/day. This decreasing phenomenon in year 2023 and year 2033 are affected by the traffic congestion in central area of Davao City.

TABLE 6.2-15 TRAFFIC INDICATOR OF WITH DAVAO BYPASS DO-NOTHING CASE ON YEAR 2018, 2023, 2033

Traffic Indicators		Year 2018	Year 2023	Year 2033
Total Vehicle Time (veh*hr/day)	With (W)	184,350	216,682	297,710
	Without (WO)	198,179	235,299	320,332
	Difference (WO-W)	13,829	18,617	22,622
Total Vehicle Km (veh*km/day)	With (W)	5,247,059	5,896,668	7,210,408
	Without (WO)	5,259,435	5,840,688	7,100,186
	Difference (WO-W)	12,376	-55,980	-110,222
Average Speed (km/h)	With (W)	28.5	27.2	24.2
	Without (WO)	26.5	24.8	22.2
	Difference (WO-W)	-2.0	-2.4	-2.0

Source: JICA Study Team

TABLE 6.2-16 (1) ESTIMATED TRAFFIC AT NORTH SECTION

Year	2018		2023		2033	
	Veh/day	(%)	Veh/day	(%)	Veh/day	(%)
Car	4,162	-	4,726	2.6%	5,544	1.6%
Jeepney	1,117	-	1,539	6.6%	1,783	1.5%
Bus	413	-	534	5.3%	465	-1.4%
Truck	2,299	-	2,539	2.0%	3,126	2.1%
Total	7,991	-	9,338	3.2%	10,917	1.6%

Source: JICA Study Team

TABLE 6.2-16 (2) ESTIMATED TRAFFIC AT CENTER SECTION

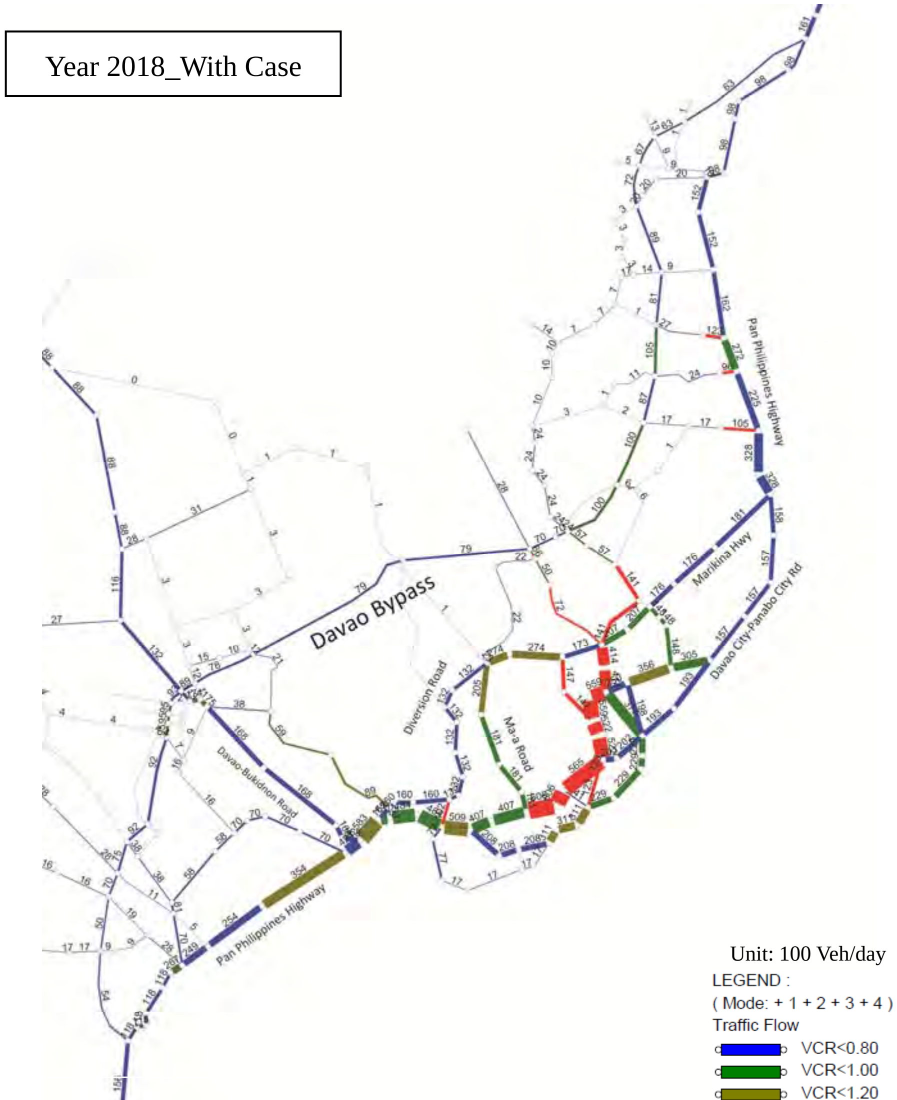
Year	2018		2023		2023	
	Count	(%)	Count	(%)	Count	(%)
Car	4,054	-	5,374	5.8%	6,090	1.3%
Jeepney	1,089	-	1,771	10.2%	1,845	0.4%
Bus	29	-	151	39.0%	55	-9.7%
Truck	2,711	-	3,321	4.1%	3,968	1.8%
Total	7,884	-	10,616	6.1%	11,957	1.2%

Source: JICA Study Team

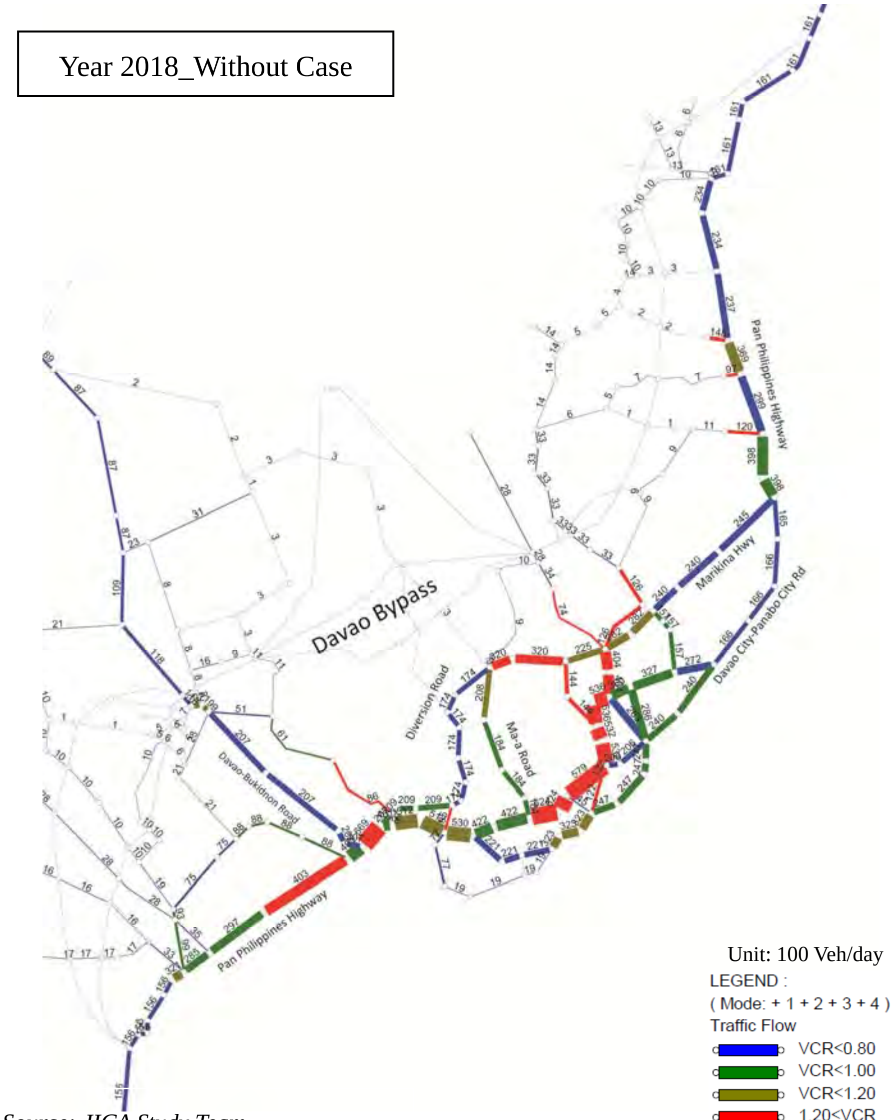
TABLE 6.2-16 (3) ESTIMATED TRAFFIC AT SOUTH SECTION

Year	2018		2023		2033	
Car	4,252	-	5,497	5.3%	6,868	2.3%
Jeepney	851	-	1,247	7.9%	1,582	2.4%
Bus	135	-	215	9.7%	254	1.7%
Truck	2,287	-	2,867	4.6%	3,554	2.2%
Total	7,524	-	9,825	5.5%	12,258	2.2%

Source: JICA Study Team

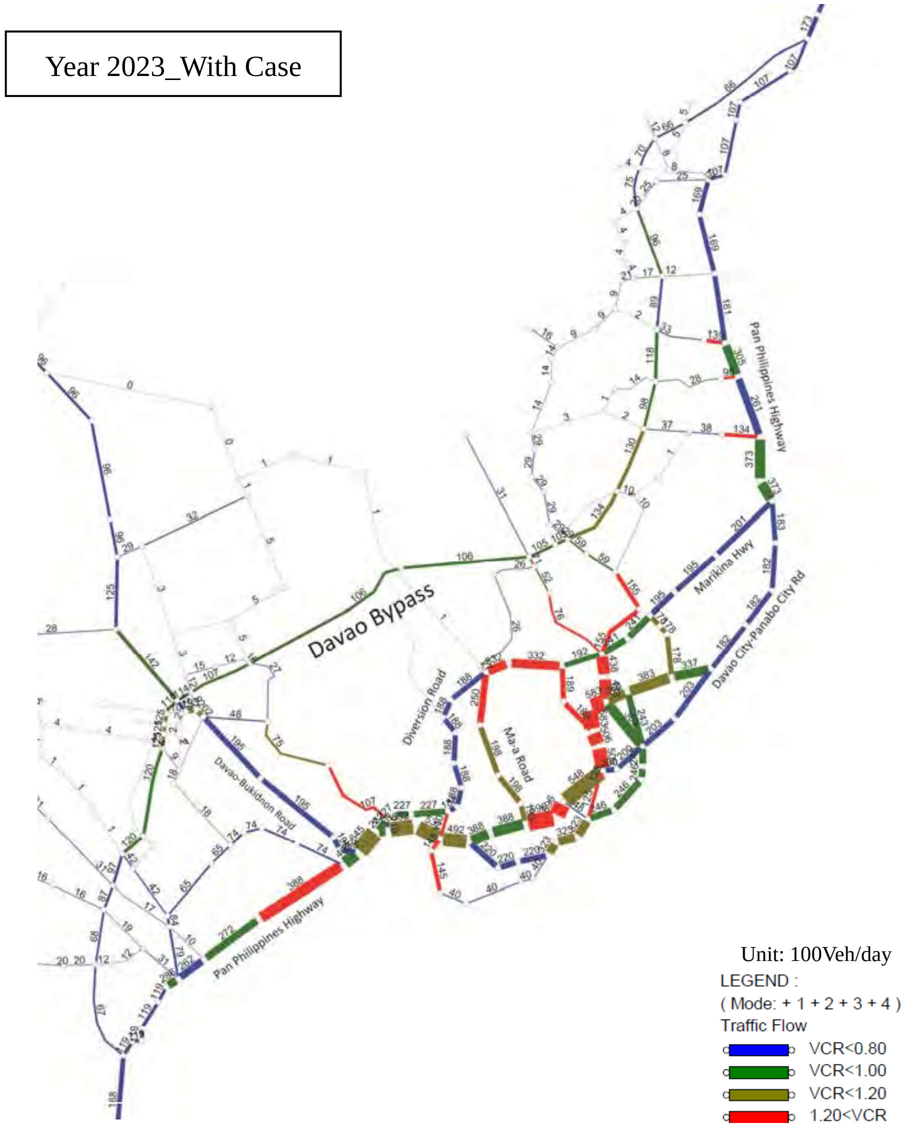


Source: JICA Study Team

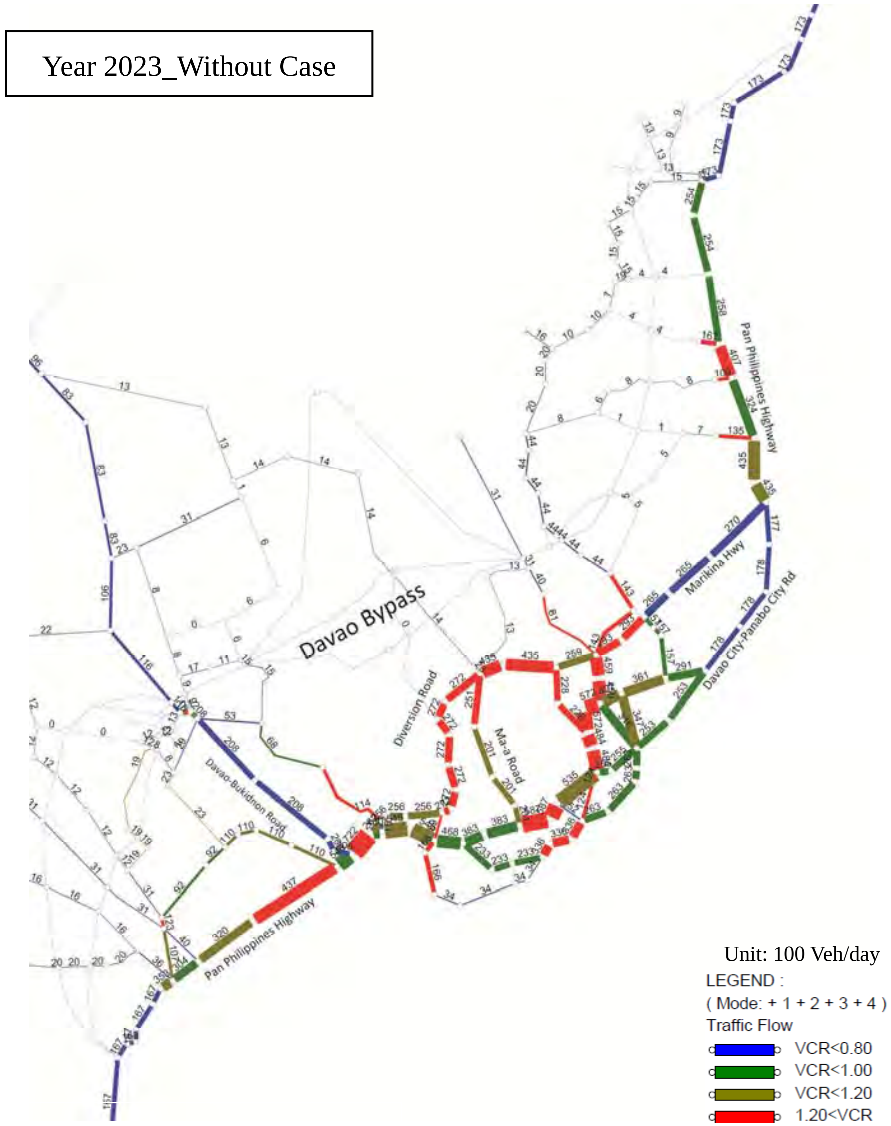


Source: JICA Study Team

FIGURE 6.2-19 RESULT OF TRAFFIC ASSIGNMENT IN YEAR 2018

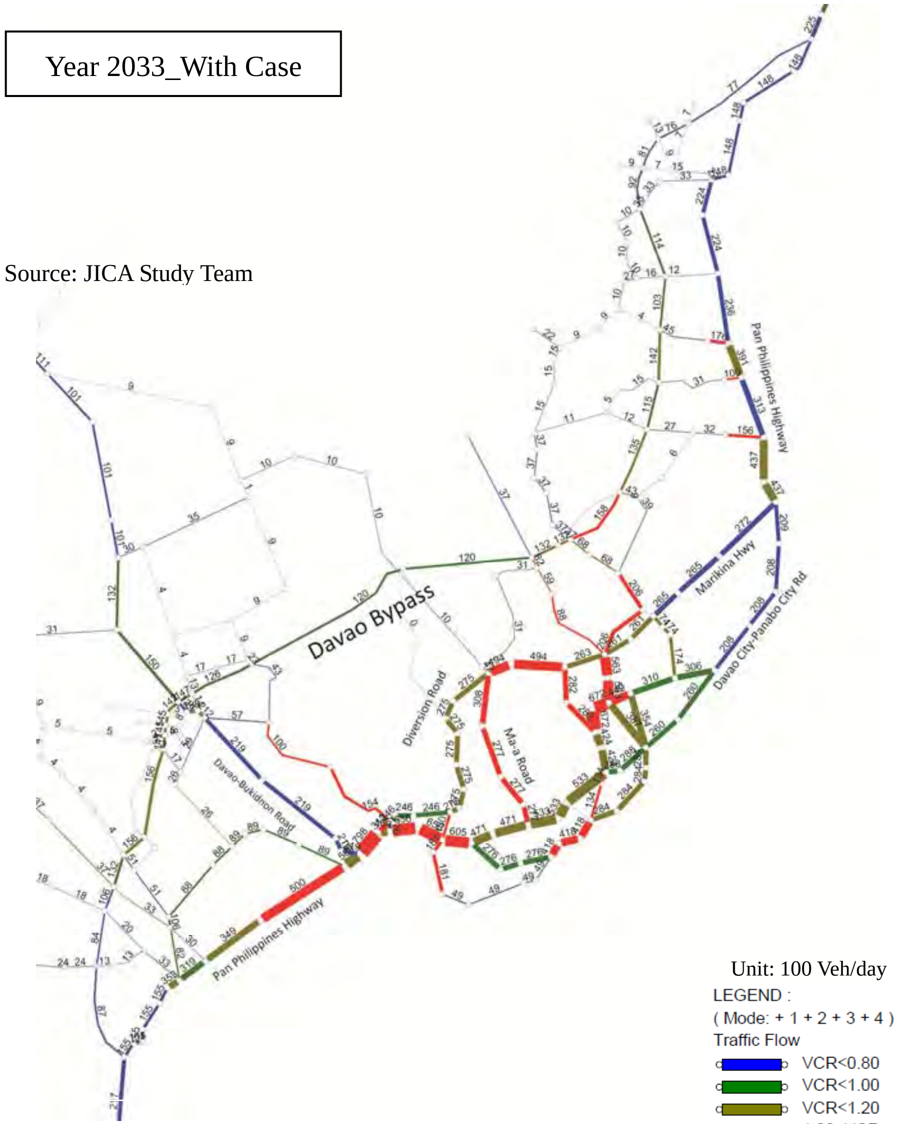


Source: JICA Study Team

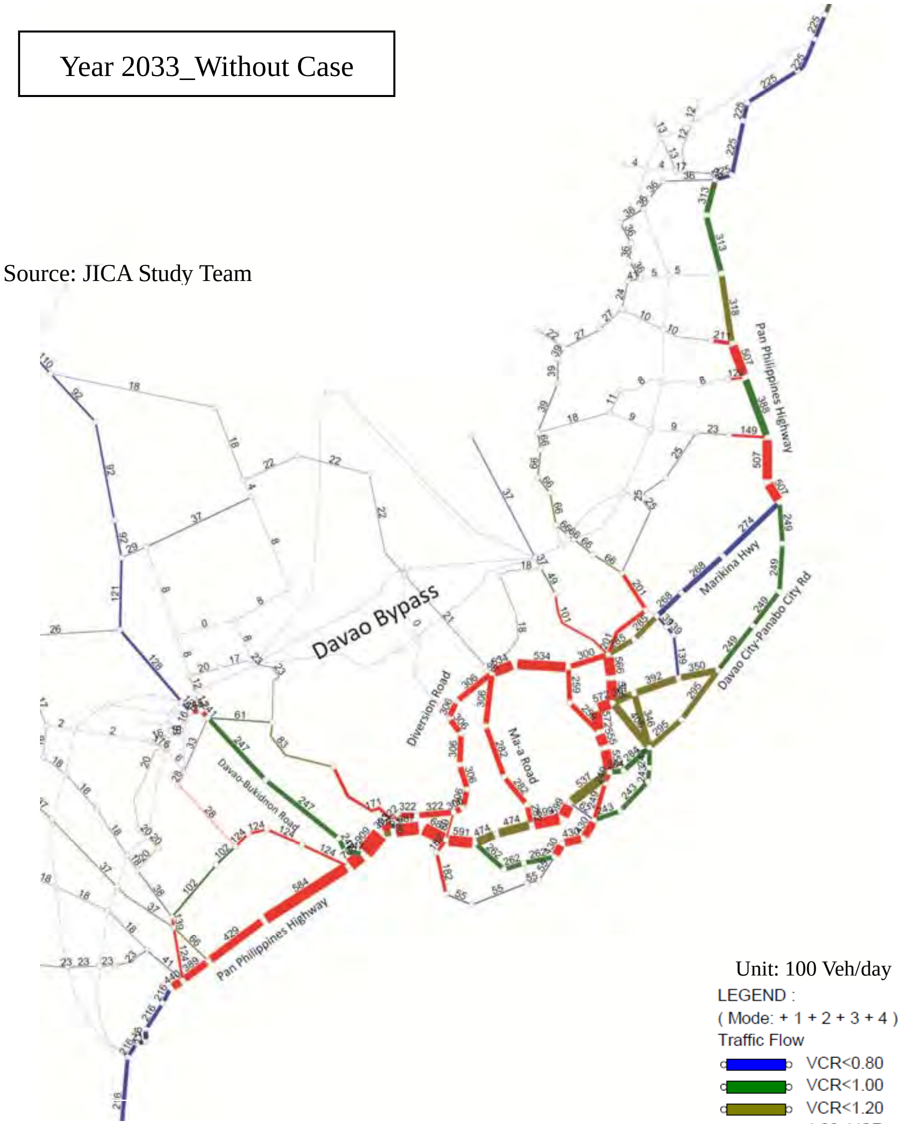


Source: JICA Study Team

FIGURE 6.2-20 RESULT OF TRAFFIC ASSIGNMENT IN YEAR 2023



Source: JICA Study Team



Source: JICA Study Team

FIGURE 6.2-21 RESULT OF TRAFFIC ASSIGNMENT IN YEAR 2033

6.2.7 Level of Service (LOS) Analysis

Definition of Level of Service (LOS) by the Highway Capacity Manual (HCM) 2000 of USA for a 2-lane highway is shown in **Table 6.2-17**.

TABLE 6.2-17 DEFINITION OF LOS FOR A TWO-LANE HIGHWAY

LOS A	The highest quality of traffic service, when motorists are able to travel at their desired speed. Without strict enforcement, this highest quality would result in average speeds of 90 km/h or more on two-lane highways.
LOS B	Traffic flow with speeds of 80 km/h or slightly higher on level-terrain Class I highways. The demand for passing to maintain desired speeds becomes significant and approximates the passing capacity at the lower boundary of LOS B.
LOS C	Further increases in flow, resulting in noticeable increases in platoon formation, platoon size, and frequency of passing impediments. The average speed still exceeds 70 km/h on level-terrain
LOS D	Unstable traffic flow. The two opposing traffic streams begin to operate separately at higher volume levels, as passing becomes extremely difficult. speeds of 60 km/h still can be maintained under base conditions
LOS E	Even under base conditions, speeds may drop below 60 km/h. Average travel speeds on highways with less than base conditions will be slower, even down to 40 km/h on sustained upgrades. the capacity of the highway, Generally 3,200 pc/h total in both directions. Operating conditions at capacity are unstable and difficult to predict.
LOS F	Heavily congested flow with traffic demand exceeding capacity. Volumes are lower than capacity and speeds are highly variable.

Source: HCM 2000

<u>**Appropriate Level of Service by AASHTO**</u>

A Policy on Geometric Design of Highways and Streets, 2011 (AASHTO) suggests the appropriate level of service for each functional class of road as follows;

TABLE 6.2-18 GUIDELINES FOR SELECTION OF DESIGN LEVEL OF SERVICE

Functional class	Appropriate level of service for specified combinations of area and terrain type			
	Rural level	Rural rolling	Rural mountainous	Urban and suburban
Freeway	B	B	C	C or D
Arterial	B	B	C	C or D
Collector	C	C	D	D
Local	D	D	D	D

Source: A Policy on Geometric Design of Highways and Streets, 2004, AASHTO

According to the above guidelines, recommended for a Bypass road are that of LOS “B” or “C”, however, the guidelines seems to be aiming quite high LOS. LOS may be lowered by one rank, say from “C or D” to “D or E”.

<u>**Service Traffic Volume of a Two-lane Bypass**</u>

In accordance with the HCM formula, the service traffic volume was estimated at 3 sections as shown in **Table 6.2-20** to **Table 6.2-22.** And, service volume for LOS is shown in **Table 6.2-19.** These were prepared in consideration with traffic situations (directional split, peak hour factor etc). The LOS of the Davao Bypass at the opening year will be “D”, and it will be “E” in year 2029. The widening to a 4-lane bypass plan should be considered when LOS reaches “E”.

TABLE 6.2-19 SERVICE TRAFFIC VOLUME OF TWO-LANE BYPASS

LOS	Service volume for LOS	
	Veh/Hour (both directions)	Veh/Day (both directions)
A	Less than 70	Less than 875
B	Less than 180	Less than 2,250
C	Less than 460	Less than 5,750
D	Less than 910	Less than 11,375
E	Less than 1,360	Less than 16,875
F	Over 1,360	Over 16,875

Consultant's estimate based on Highway Capacity Manual 2000 (HCM2000)
Note: Assumptions: Rural Area, 34 percent truck and bus; 14 percent Jeepney; free flow speed; 60km/hr.

TABLE 6.2-20 ESTIMATED TRAFFIC VOLUME (NORTH SECTION)

Year	Daily Traffic Assignment (veh./day)	Peak Hour Traffic Volume (veh./hour)	LOS	Volume/Capacity Ratio
	(a)	(b = a * 0.08)		
2018	7,991	639	D	0.47
2019	8,244	659		0.49
2020	8,505	680		0.50
2021	8,774	702		0.52
2022	9,052	724		0.54
2023	9,338	747		0.55
2024	9,485	759		0.56
2025	9,634	771		0.57
2026	9,786	783		0.58
2027	9,940	795		0.59
2028	10,097	808		0.70
2029	10,255	820		0.71
2030	10,417	833		0.72
2031	10,581	846		0.74
2032	10,747	860		0.75
2033	10,917	873		0.76
2034	11,190	895		0.78
2035	11,469	918	E	0.80
2036	11,756	940		0.82
2037	12,050	964		0.84
2038	12,351	988		0.86

Source: JICA Study Team

TABLE 6.2-21 ESTIMATED TRAFFIC VOLUME (CENTER SECTION)

Year	Daily Traffic Assignment (veh./day)	Peak Hour Traffic Volume (veh./hour)	LOS	Volume/Capacity Ratio
	(a)	(b = a * 0.08)		
2018	7,884	631	D	0.47
2019	8,367	669		0.50
2020	8,880	710		0.53
2021	9,425	754		0.56
2022	10,003	800		0.59
2023	10,616	849		0.63
2024	10,743	859		0.64
2025	10,872	870		0.64
2026	11,002	880		0.65
2027	11,134	891		0.66
2028	11,267	901		0.78
2029	11,402	912	E	0.79
2030	11,538	923		0.80
2031	11,676	934		0.81
2032	11,816	945		0.82
2033	11,957	957		0.83
2034	12,256	980		0.85
2035	12,563	1,005		0.87
2036	12,877	1,030		0.90
2037	13,199	1,056		0.92
2038	13,528	1,082		0.94

Source: JICA Study Team

TABLE 6.2-22 ESTIMATED TRAFFIC VOLUME (SOUTH SECTION)

Year	Daily Traffic Assignment (veh./day)	Peak Hour Traffic Volume (veh./hour)	LOS	Volume/Capacity Ratio
	(a)	(b = a * 0.08)		
2018	7,524	602	D	0.45
2019	7,937	635		0.47
2020	8,372	670		0.50
2021	8,831	706		0.52
2022	9,315	745		0.55
2023	9,825	786		0.58
2024	10,045	804		0.60
2025	10,270	822		0.61
2026	10,499	840		0.62
2027	10,734	859		0.64
2028	10,974	878		0.76
2029	11,220	898		0.78
2030	11,471	918	E	0.80
2031	11,727	938		0.82
2032	11,990	959		0.83
2033	12,258	981		0.85
2034	12,564	1,005		0.87
2035	12,878	1,030		0.90
2036	13,200	1,056		0.92
2037	13,530	1,082		0.94
2038	13,869	1,109		0.96

Source: JICA Study Team

6.2.8 Effect of Toll for Tunnel Section

(1) General

Since operation for tunnel section requires much electricity for lighting, jet fans and other facilities during the 24-hour, operation cost of the tunnel section will be much higher than that of the roadway section.

To solve the above issue, one option is to collect toll for covering the tunnel section's operation and maintenance cost.

This section describes the traffic study of toll for tunnel section.

(2) Time Evaluation Value

An important input for the demand forecast of toll road is the trip maker's time value. This time value is the basis for a trip maker to decide whether to use toll road or not. The time values were derived from MMUEN (JICA, The Development of the Public-Private Partnership Technique from the Metro Manila Urban Expressway Network) survey results. Though MMUEN data is based on the Metro Manila and surrounding area, Time Evaluation Value in Region XI is lower than that of MMUEN. Based on the rate of GRDP per capita (GRDP per capita of Region XI/that of NCR and Region XI = 91,312 pesos / 282,199 pesos = 0.320), Time Evaluation Value in Region XI was set.

Supposing time value in the future will increase in accordance with inflation rate of 5.5% per year, the figures in **Table 6.2-23** will be the time value.

TABLE 6.2-23 TIME EVALUATION VALUE BY VEHICLE TYPE

Unit: Peso/hour

Area	MMUEN (Metro Manila and Surrounding Areas)		Region XI (Study Area)	
Year	**2009**	**2013**	**2013**	**2018**
		(a)	*(b = a x 0.320)*	*(c = b x 1.055^5)*
Car	331	429	137	179
Jeepney	465	600	192	251
Bus	1,524	2,000	640	836
Truck	873	1,200	384	502

Source: JICA Study Team

(3) Case Study

The traffic assignment of the following case was conducted to estimate the number of vehicles and revenues.

TABLE 6.2-24 TOLL FEE SETTING

(Peso)

	Class 1 (Car, Jeepney, Pick-up)	Class 2 (Light Truck)	Class 3 (Heavy Truck, Trailer)
Case-0	Free	Free	Free
Case-1	5	10	15
Case-2	10	20	30
Case-3	20	40	60
Case-4	30	60	90
Case-5	40	80	120
Case-6	50	100	150

Source: JICA Study Team

(4) Toll Rate vs. Revenue

The traffic volume at the tunnel section and the amount of revenue are estimated by the traffic assignment model. **Figure 6.2-22** shows the result of traffic assignment of toll rate in year 2018.

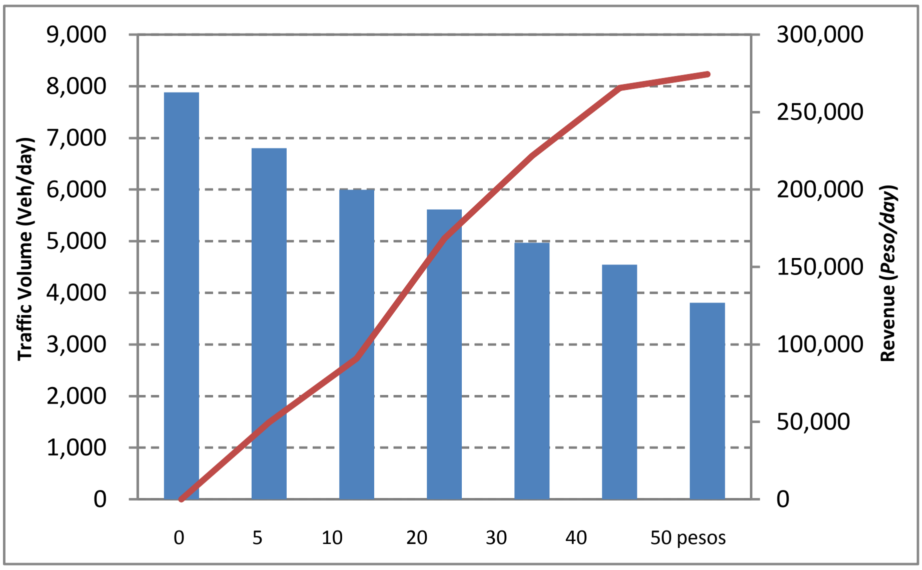
- In case of toll free, traffic volume of tunnel section is 7,883 vehicles/day.
- The objective of toll collection is to acquire the O & M Cost for tunnel section. Though O & M cost for tunnel section is described in Chapter 14, 10 or 20 pesos for Class I will be required to collect toll for tunnel O & M.

TABLE 6.2-25 ESTIMATED TRAFFIC VOLUME

Unit: Pesos

	Traffic Volume (vehicle/day)				Revenue (day)	Revenue (Year)
	Class1	Class2	Class3	Total		
Case 0 (Free)	5,143	2,285	455	7,883	0	0
Case 1 (5Php)	4,103	2,251	447	6,801	49,732	18,152,123
Case 2 (10Php)	3,344	2,216	436	5,996	90,840	33,156,478
Case 3 (20Php)	3,207	2,006	402	5,615	168,502	61,503,196
Case 4 (30Php)	2,892	1,728	347	4,967	221,673	80,910,606
Case 5 (40Php)	2,747	1,495	300	4,542	265,486	96,902,335
Case 6 (50Php)	2,360	1,209	237	3,806	274,463	100,179,112

Source: JICA Study Team



Source: JICA Study Team

FIGURE 6.2-22 TOLL RATE VS. REVENUE (YEAR 2018)

CHAPTER 7
NECESSITY OF THE PROJECT

7.1 PRESENT AND FUTURE URBAN STRUCTURE

(1) Definition of Urban Center

Urban Center is defined by this study as follows;

AREA OF URBAN CENTER

- All barangays of Poblacion District
- All barangays of Agdao District
- Six (6) barangays of Talomo District
  - Barangay of Ma-a, Matina Pangi, Matina Crossing, Matina Aplaya, Talomo Proper and Bucana
- Three barangays of Buhangin District
  - Barangays of Buhangin, Sasa and Pampanga

(2) Present Urban Structure

Schematic urban structure is shown in **Figure 7.1-1.**

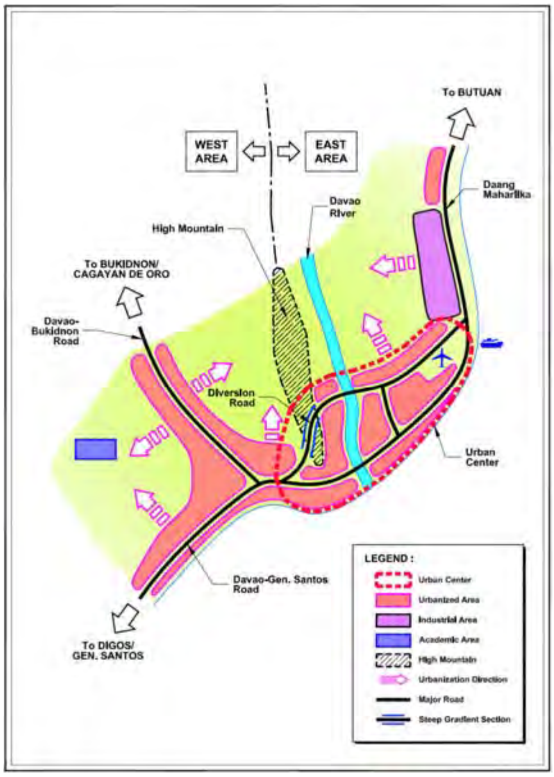
Urbanization is progressing in the Urban Center and areas along major roads (national roads) of Daang Maharlika in the north, Davao-Bukidnon Road in the west, Davao-General Santos Road in the south and Diversion Road along the boundary of Urban Center.

Industrial area is developed along Daang Maharlika.

Davao International Airport and Sasa Port (international port) are located in the Urban Center.

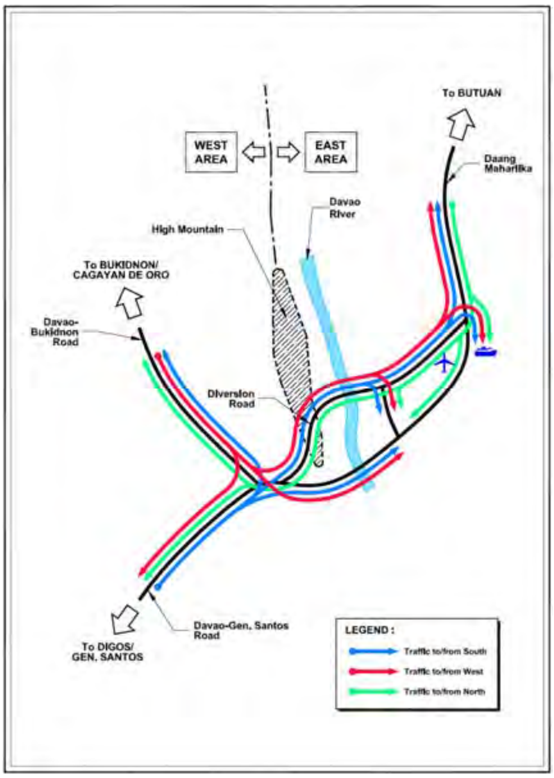
The Study Area is physically divided into two (East Area and West Area) by Davao River and a high mountain which restrict movement of people and goods.

<u>Urbanization Trend:</u> Urbanization trend is seen towards the inland areas along narrow City Roads. Many large scale housing (subdivision) development is on-going.



Source: JICA Study Team

FIGURE 7.1-1 SCHEMATIC URBAN STRUCTURE



Source: JICA Study Team

FIGURE 7.1-2 TRAFFIC MOVEMENT

(3) Traffic Movements

Traffic movements to/from the north, west and south from/to Urban Center rely on national roads of Daang Maharlika, Davao-Bukidnon Road and Davao-General Santos Road. Traffic from the north, west and south is distributed by the Diversion Road.

Most roads within the Urban Center except the Diversion Road are heavily congested and traffic speed is less than 20km/hour. Thus, many drivers are selecting the Diversion Road instead of other roads in Urban Center, even though travel distance becomes much longer when they select the Diversion Road.

<u>Truck Ban</u> from 6:00 A.M. to 9:00 A.M. and from 5:00 P.M. to 8:00 P.M. is imposed on roads within the Urban Center except the Diversion Road. Thus, trucks are concentrating on the Diversion Road.

<u>Diversion Road</u> is becoming very important road not only for Davao City but for entire Mindanao. It has 4 to 6 lanes and its road sides are being developed as commercial areas and residential areas, therefore, local traffic is drastically increasing and traffic flow of through traffic is being affected. Another serious issue is that it climbs up and down the mountain <u>with steep gradient of 6.5% to 7%,</u> therefore, loaded trucks can only travel with slow speed of 20-25km/hour. Due to truck ban imposed in the Urban Center, all trucks have to use this road, slow travel speed due to steep gradient will aggravate overall transport efficiency of Davao City.

(4) Problems of the Urban Center

- **<u>Overconcentration of population in the narrow Urban Center:</u>** About 45% of Davao City population (or 652,600 people out of 1,449,000 population of Davao City) is settled in the 3% of land area of Davao City (or 73 sq.km. out of 2,440 sq.km. of Davao City). An average population density of the Urban Center reached to 89 persons/hectare. Population growth rate of the Urban Center is lower than that of Davao City.Thus, urbanization is expanding towards the inland areas.

TABLE 7.1-1 CHARACTERISTICS OF URBAN CENTER

	Davao City	Urban Center
Land Area	2,440 sq. km.	73 sq. km. (3% of Davao City)
Population (2010)	1,449,296	652,607 (45% of Davao City)
Population Density	5.9 person/ha.	89.4 person/ha. (15 times of Davao City)
Population Growth Rate (2007-2010)	2.19% per annum	1.07% per annum

Source: Prepared by JICA Study Team based on NSO, Davao City data

- **Overconcentration of economic activities** in the Urban Center: Large scale shopping malls, banks and other financial institutions, universities, government offices are concentrated in the Urban Center.

- **Concentration of major transport facilities** in the Urban Center: International port and airport and bus terminals are located in the Urban Center.

- **Chronic Traffic Congestion:** Traffic congestion of roads in the Urban Center is chronic. Travel speeds of most roads are less than 20km/hr.

- **Concentration of diverted vehicles/truck traffic on Diversion Road:** Traffic which used to pass through the urban Center is now diverting to the Diversion Road. Most trucks are using the Diversion Road due to truck ban in the Urban Center. In addition to above, local traffic on the Diversion Road is increasing due to commercial activities along the Diversion Road. Du to steep gradient of climbing up the mountain, loaded trucks can travel only with low speed which is hampering smooth travel. It is expected that the Diversion Road will experience heavy traffic congestion in the near future.

7.2 TRAFFIC CHARACTERISTICS

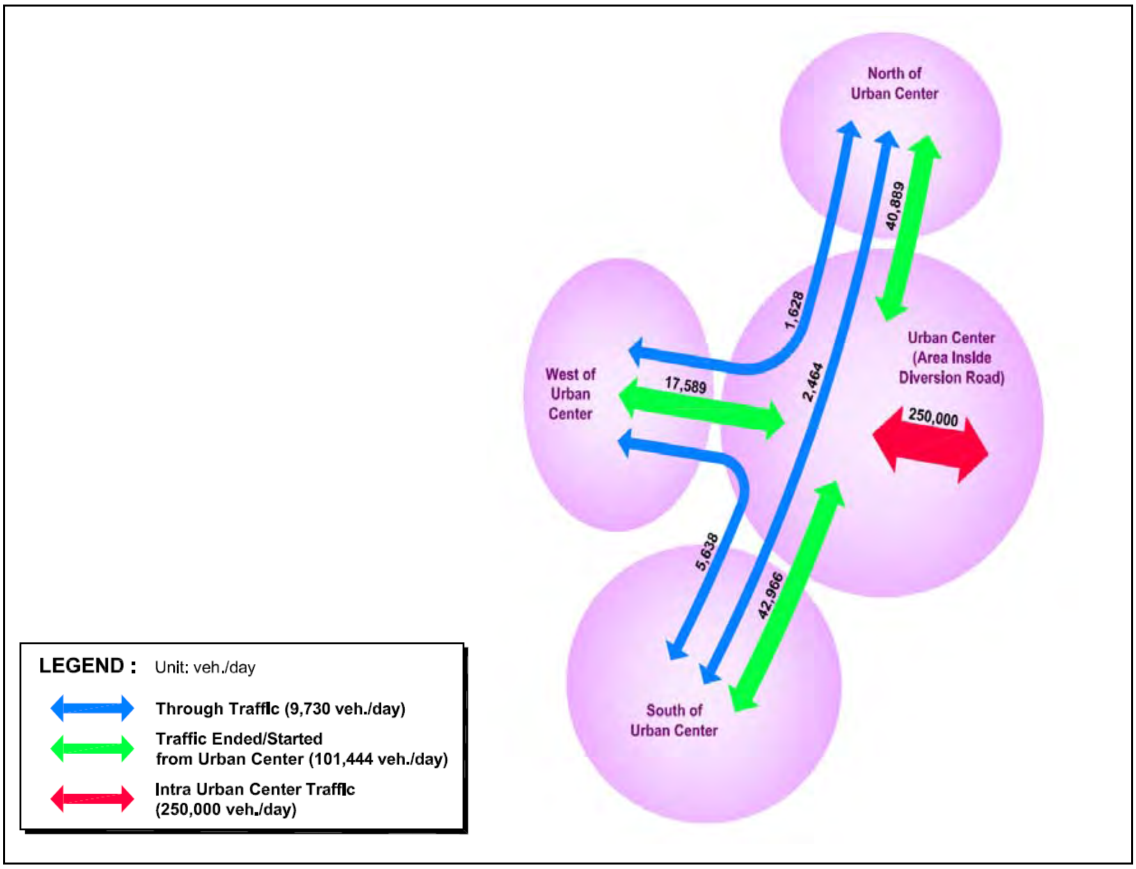
(1) Overall Traffic Characteristics

Based on the traffic surveys undertaken in August 2013, traffic flow is estimated as shown in **Figure 7.2-1** and summarized below:

Through Traffic: Traffic which passes through the Urban Center is 9,730 veh./day (=1,628 + 2,464 + 5,638)

Urban Center Related Traffic: Traffic which starts or end at the Urban Center from/to the north, the west and the south is 101,444 veh./day.

Intra Urban Center Traffic: Traffic which moves within Urban Center is 250,000 veh./day.



Source: JICA Study Team

FIGURE 7.2-1 TRAFFIC CHARACTERISTICS

(2) Traffic Desire Line

Traffic desire line which shows O-D pattern of Traffic Zone 1 (Poblacion), Traffic Zone 3 (Matina/Talomo), traffic zones north of Davao City, traffic zones west of Davao City, traffic zones south of Davao City and track O-D pattern of Sasa Port is shown in **Figure 7.2-2.**

Traffic Zone-1 (Poblacion): Heavily traffic movements between Poblacion and traffic zones along the coastal line and between south as well as north areas outside Davao City.

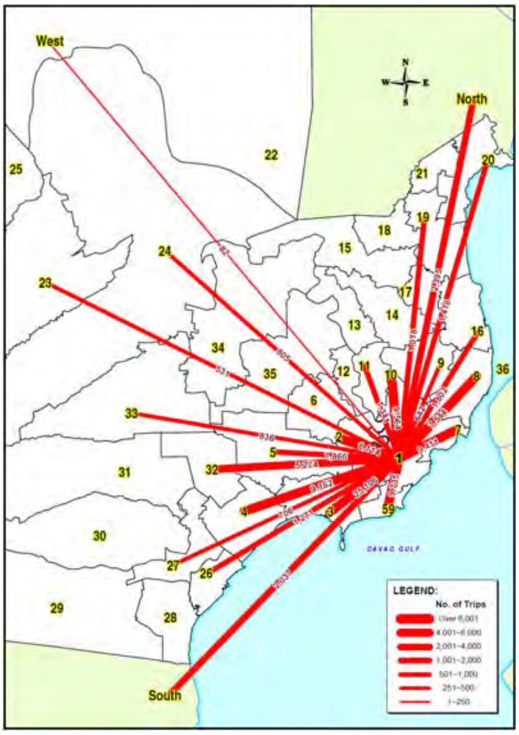
Traffic Zone-3 (Matina/Talomo): Heavy traffic movements between Matina/Talomo and traffic zones along the coastal line.

Traffic Zones North of Davao City: Heavy traffic movements between North of Davao City and Poblacion and its surrounding zones.

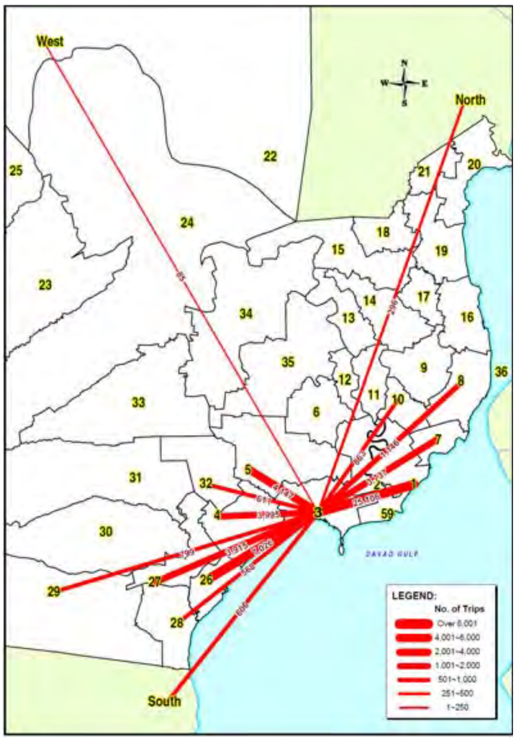
Traffic Zones West of Davao City: No strong traffic movements with specific traffic zones.

Traffic Zones South of Davao City: Relatively strong relation with Poblacion and its surrounding traffic.

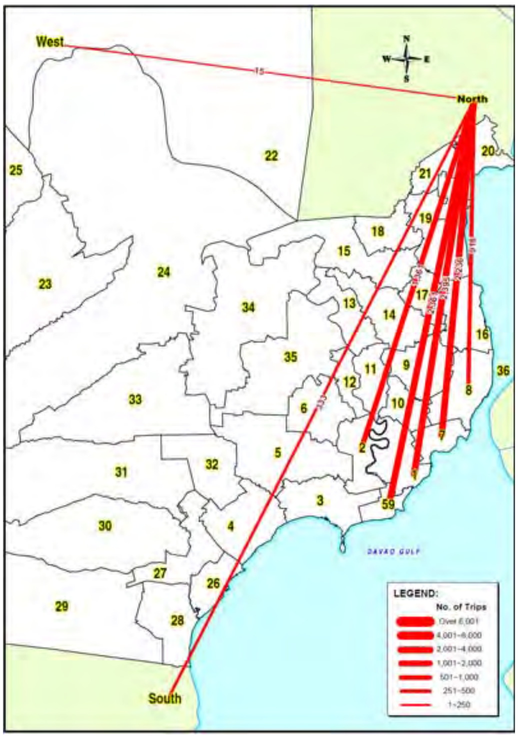
Sasa Port: Relatively strong movements between Sasa Port and nearby traffic zones where industrial areas/warehouses are located. Traffic relation with South and North of Davao City is also relatively strong.



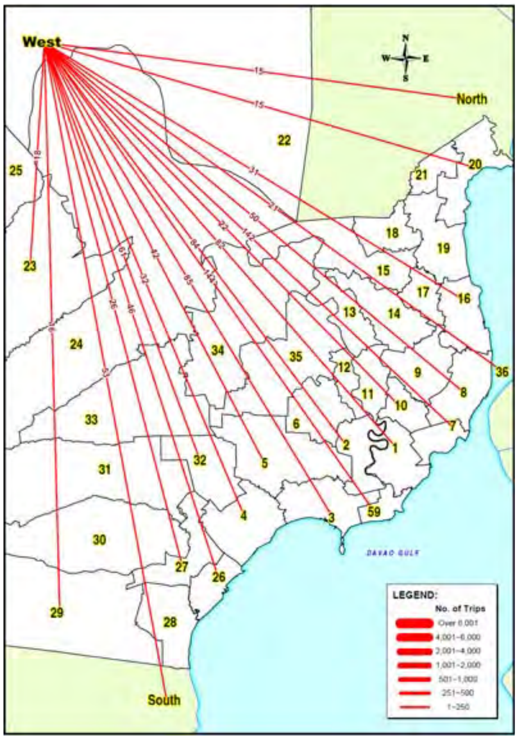
DESIRED LINE RELATED TO ZONE-1: POBLACION



DESIRED LINE RELATED TO ZONE-3: MATINA/TALOMO

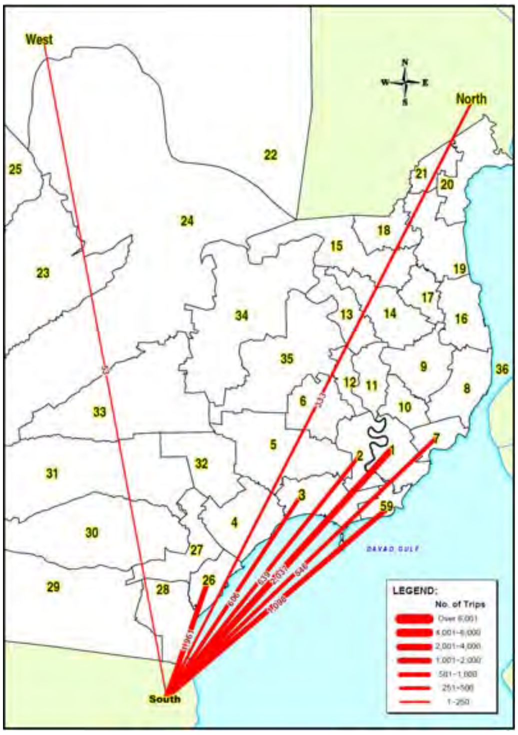


DESIRED LINE RELATED TO ZONES NORTH OF DAVAO CITY

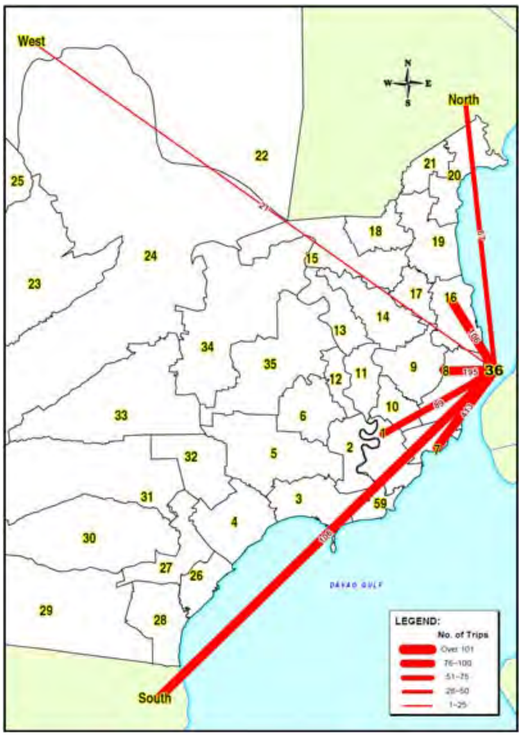


DESIRED LINE RELATED TO ZONES WEST OF DAVAO CITY

FIGURE 7.2-2 (1/2) TRAFFIC DESIRE LINE



DESIRED LINE RELATED TO ZONES SOUTH OF DAVAO CITY



TRUCK DESIRED LINE RELATED TO SASA PORT

Source: JICA Study Team

FIGURE 7.2-2 (2/2) TRAFFIC DESIRE LINE

7.3 INTERVIEW RESULTS OF MANUFACTURING /AGRI-BUSINESS COMPANIES

A total of ten (10) manufacturing/agri-business companies were interviewed mainly to identify transport problems. Transport routes of raw materials and finished products, transport problems they are encountering and expected benefits they will enjoy were interviewed.

(1) Company A (see Figure 7.3-1)

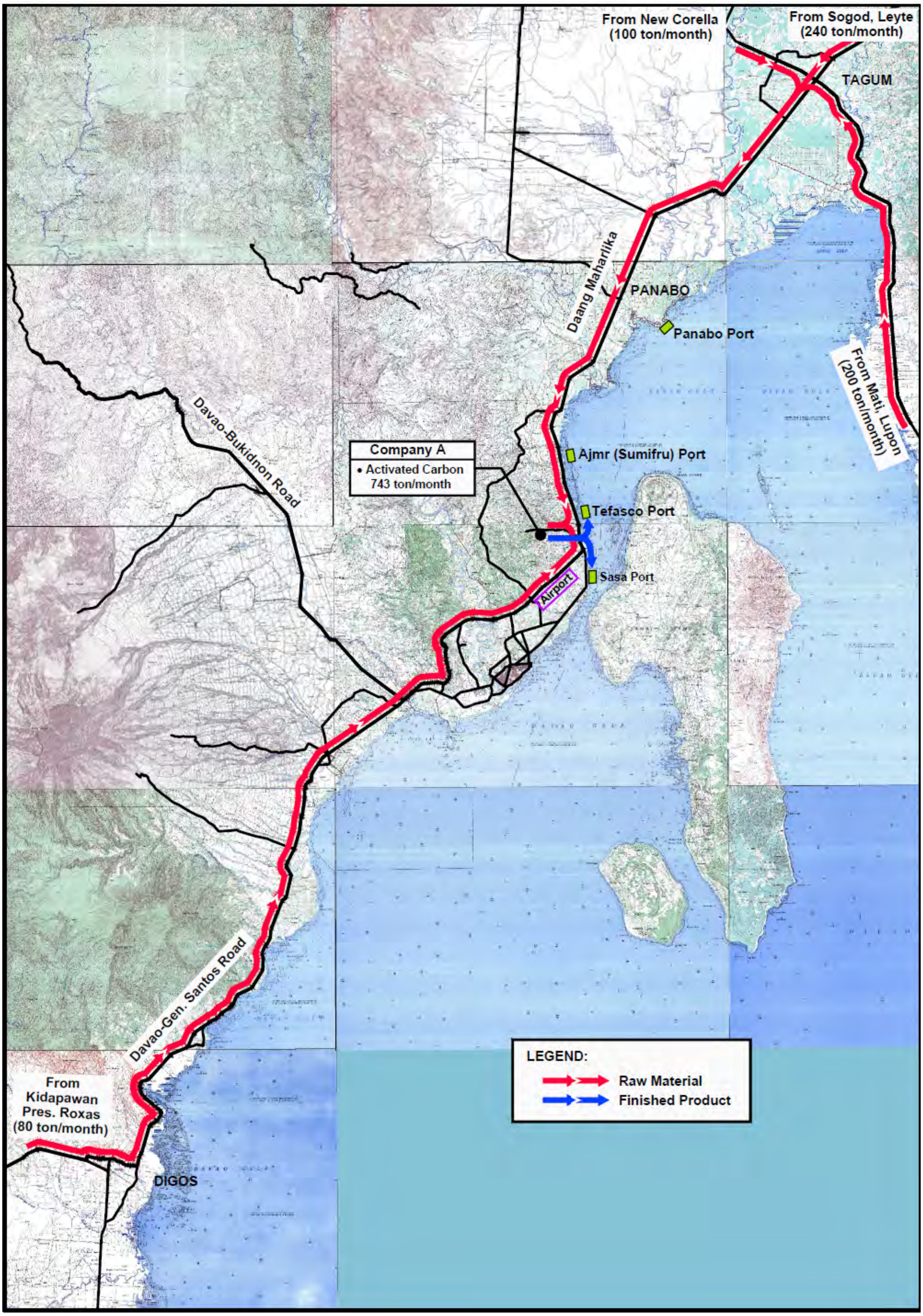
- Producing activated carbon from coconut shell charcoal
- Produces 450 Mt of activated carbon monthly
- Finished products are mostly for export to Japan, Europe and Korea
- Raw materials are being transported from all-over south and north of Mindanao and also from Leyte
- Transport routes of raw materials are as follows;
  - South of Mindanao : Cotabato – Digos – Davao Road
  - North of Mindanao : Daang Maharlika
- Transport routes of finished products
  - Transported to Sasa Port and TEFASCO Port for export

(2) Company B (see Figure 7.3-2)

- The factory is located at Digos
- Producing building materials, kitchen set, metal roofing, unit baths, etc., which are all for export to Japan (95%) and Korea (5%)
- Raw materials come from all-over Mindanao, (from Zamaboanga, Cagayan de Oro, Bukidnon, Butuan and Agusan)
- Transport routes are Cotabato-Digos Road from the south, Davao-Bukidnon Road from the west and Daang Maharlika from the north
- Finished products are exported from Sasa Port and Panabo Port

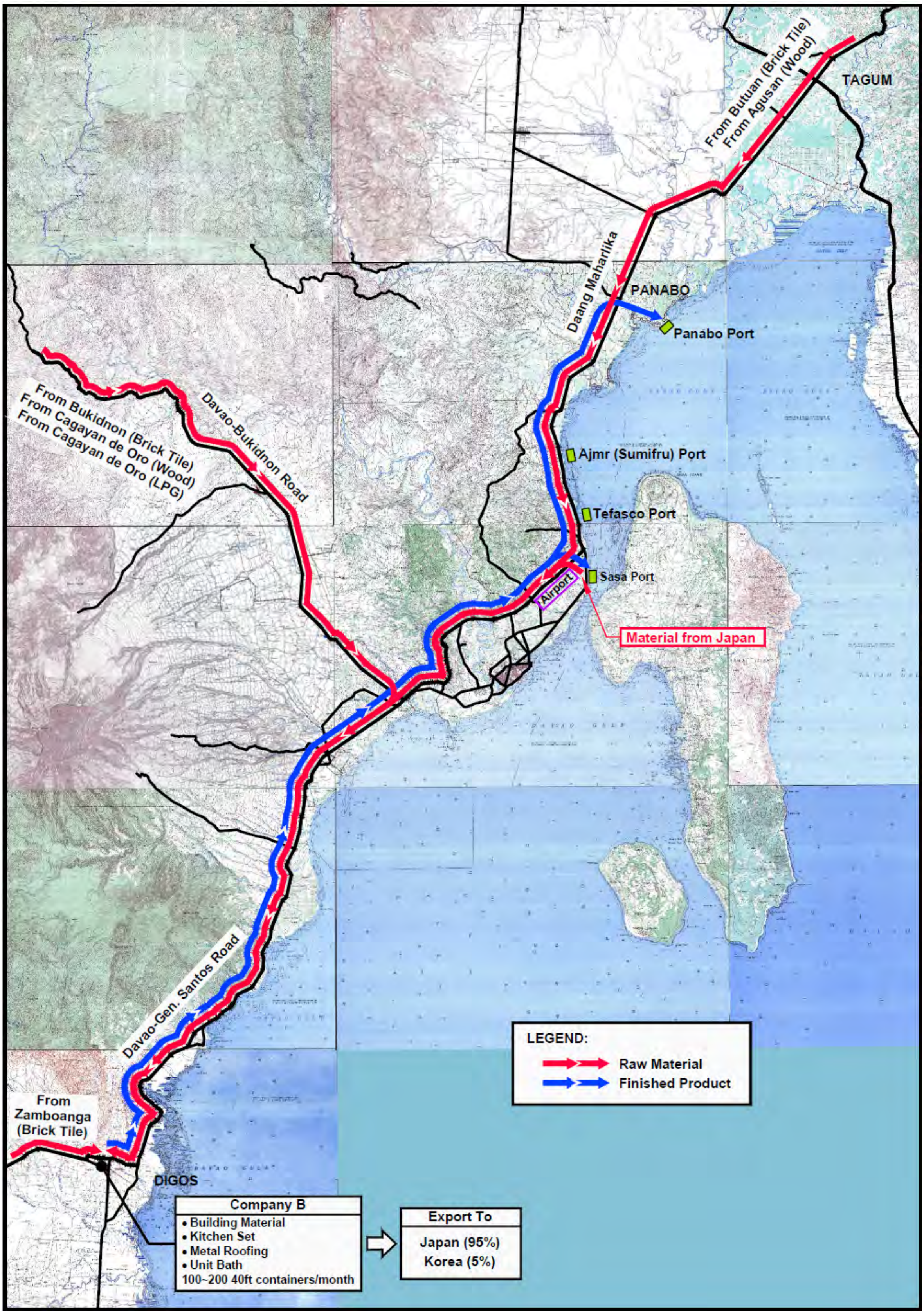
(3) Company C (see Figure 7.3-3)

- Exporting bananas, pineapples, papayas, asparagus and corns to Japan, Middle East, China, Korea, etc.
- Materials necessary for farming are unloaded at Sasa Port, TEFASCO Port and Panabo Port and transported all over /Mindanao utilizing Daang Maharlika, Davao-Bukidnon Road, Davao-Gen. Santos Road.
- Produced fruits and vegetables are exported from Sasa Port and Panabo Port by way of the same routes used for material transportation.



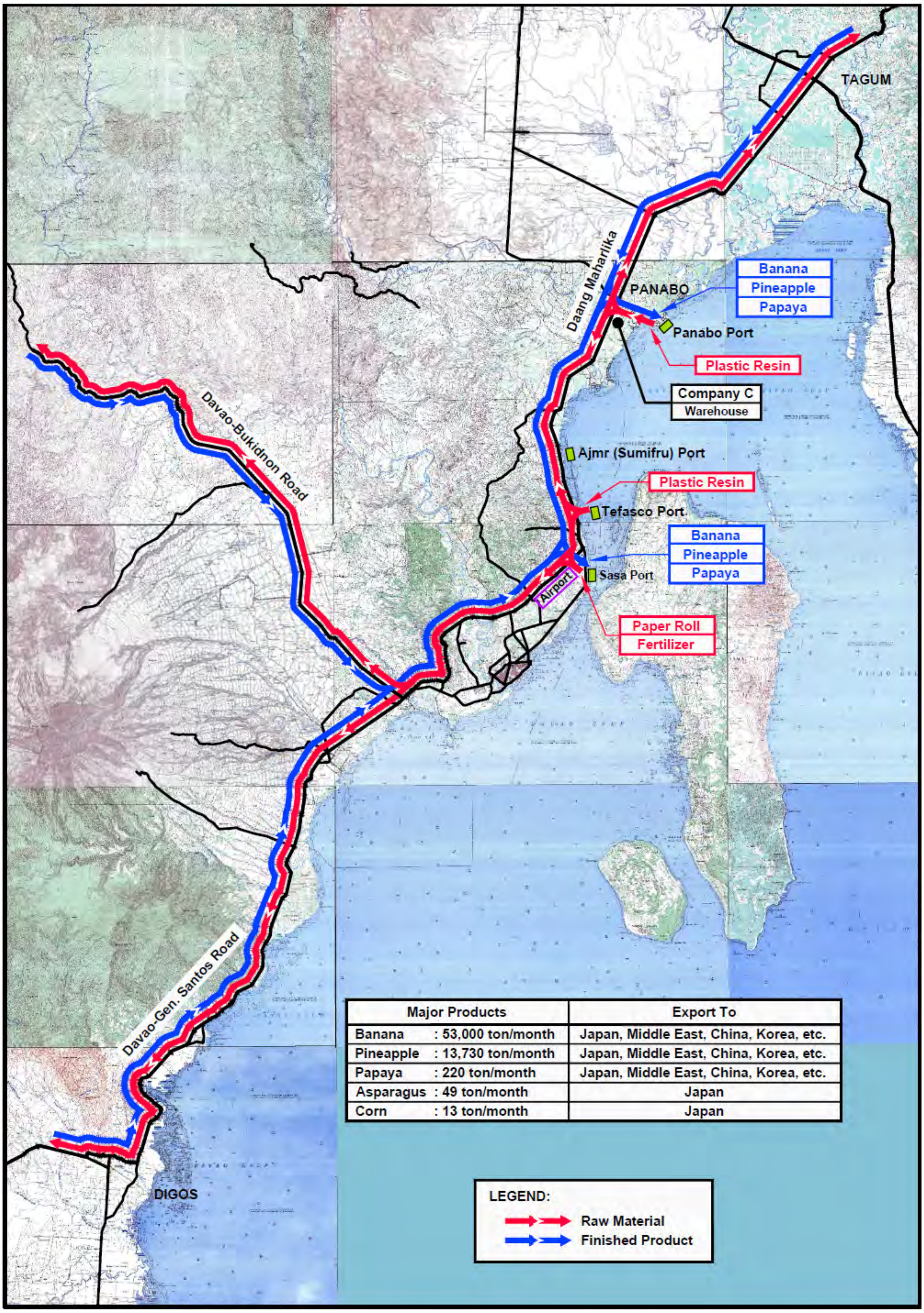
Source: JICA Study Team

FIGURE 7.3-1 TRANSPORT ROUTE OF RAW MATERIAL AND FINISHED PRODUCT: COMPANY A



Source: JICA Study Team

FIGURE 7.3-2 TRANSPORT ROUTE OF RAW MATERIAL AND FINISHED PRODUCT: COMPANY B



Major Products	Export To
Banana : 53,000 ton/month	Japan, Middle East, China, Korea, etc.
Pineapple : 13,730 ton/month	Japan, Middle East, China, Korea, etc.
Papaya : 220 ton/month	Japan, Middle East, China, Korea, etc.
Asparagus : 49 ton/month	Japan
Corn : 13 ton/month	Japan

Source: JICA Study Team

FIGURE 7.3-3 TRANSPORT ROUTE OF RAW MATERIAL AND FINISHED PRODUCT: COMPANY C

(4) Transport problems they are encountering

Their answers are summarized in **Table 7.3-1.**

TABLE 7.3-1 TRANSPORT PROBLEMS

	Problems	Number of Companies answered "Yes" out of 10 companies
1	Unpredictable arrival time of raw materials and products due to traffic congestion	10
2	High transport cost due to bad road construction	6
3	Trucks are having a hard time to travel due to steep gradient of road	6
4	Poor accessibility to Port/Airport	4
5	Are your employees experiencing traffic problems	7
6	Any other transport/traffic problems	• No shoulder roads for pedestrians • Traffic congestion in the Urban Center • Traffic problems at Panacan, Tibungco, due to commercial activities along the National Road • Never ending road repairs

Source: JICA Study Team

(5) Possible Benefits From the Bypass Project

Their answers are summarized in **Table 7.3-2.**

TABLE 7.3-2 POSSIBLE BENEFIT FROM BYPASS PROJECT

	Problems	Number of Companies answered "Yes" out of 10 companies
1	Faster delivery of cargo	10
2	Delivery of Cargo on Time	9
3	Increase access to source of materials	9
4	Transport cost reduction	9
5	Minimize damage on cargo	9
6	Others	• Smooth travel • Reduce travel time

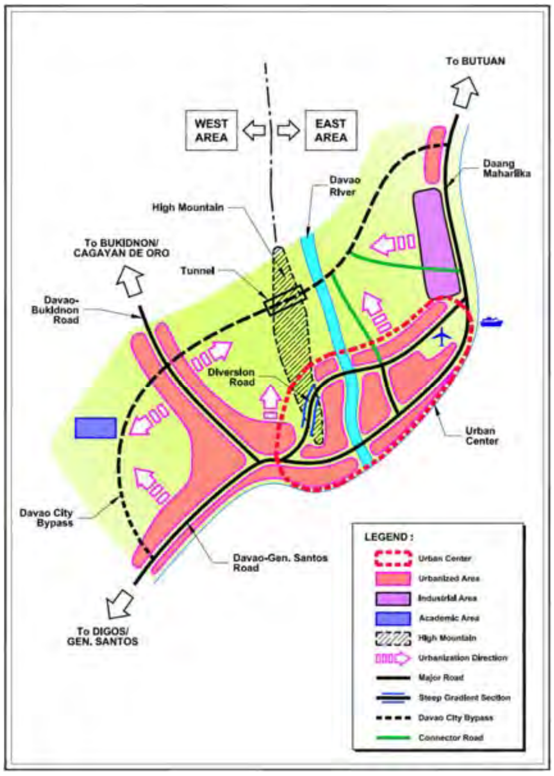
Source: JICA Study Team

7.4 NECESSITY OF DAVAO CITY BYPASS

Davao City Bypass is necessary due to the following reasons;

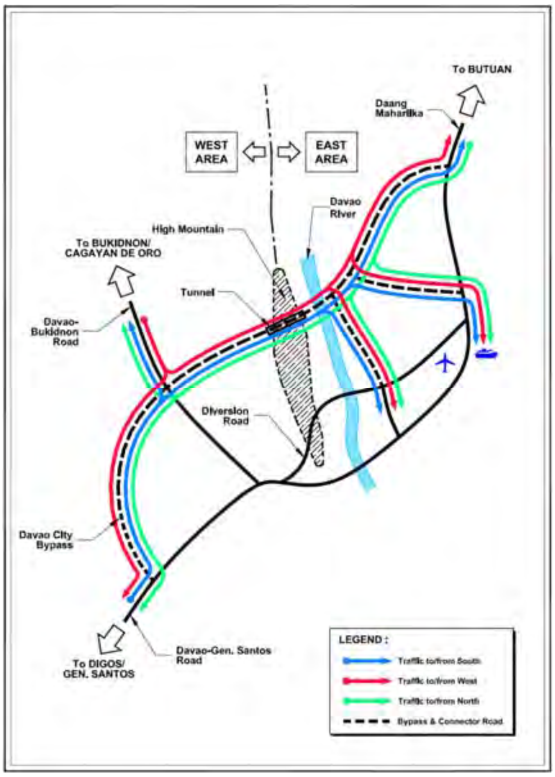
- Traffic condition in the Urban Center is chronic. Traffic which does not need to pass through the Urban Center should be diverted to the Bypass, thus a Bypass contributes to reduce traffic problems in the Urban Center.
- The Urban Center of Davao City is over saturated. Urban environment is getting worse. Urban areas must be expanded. Urbanization towards the inland areas should be orderly guided by a new road network which is Davao City Bypass.
- To strongly support economic activities, particularly manufacturing and agri-business industries of not only in the city but also in Mindanao as a whole, road transport access to the ports and the airport must be strengthened. Davao City Bypass will provide smooth access to ports and the airport.
- To support a stong road network in Davao City, especially in case of a major disaster. The

Davao Bypass Road should be constructed with a high standard of safety and strong enough which could function as an emergency route in case of major disaster that would be able to maintain and sustain the social and economic activities of the area.



Source: JICA Study Team

FIGURE 7.4-1 SCHEMATIC URBAN STRUCTURE WITH BYPASS



Source: JICA Study Team

FIGURE 7.4-2 POSSIBLE TRAFFIC DIVERTED TO THE BYPASS

7.5 DAVAO SASA PORT AS PPP PROJECT

The Department of Transportation and Communication (DOTC) is currently undertaking the feasibility study for Sasa Port as a key or flagship project for the Public-Private Partnership of the Philippine Government. The Davao Bypass Project would be substantial in the accessibility of the Davao Sasa Port. Davao Sasa Port would subsequently enhance the economic viability of the Davao City Bypass. Container traffic for the Davao Sasa Port is forecasted to double up in the next five years as shown in **Figure 7.5-1** below.

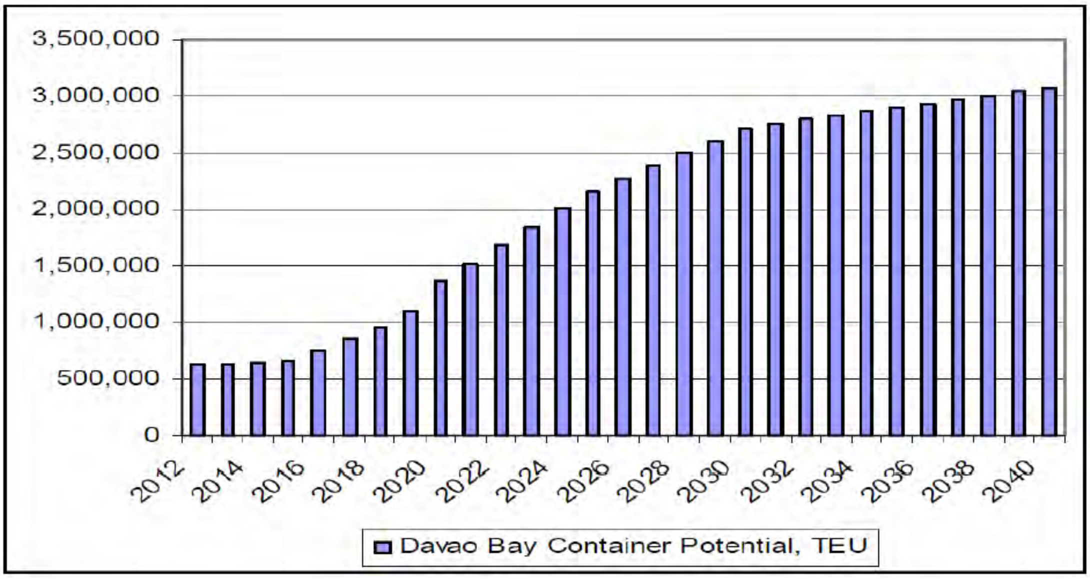
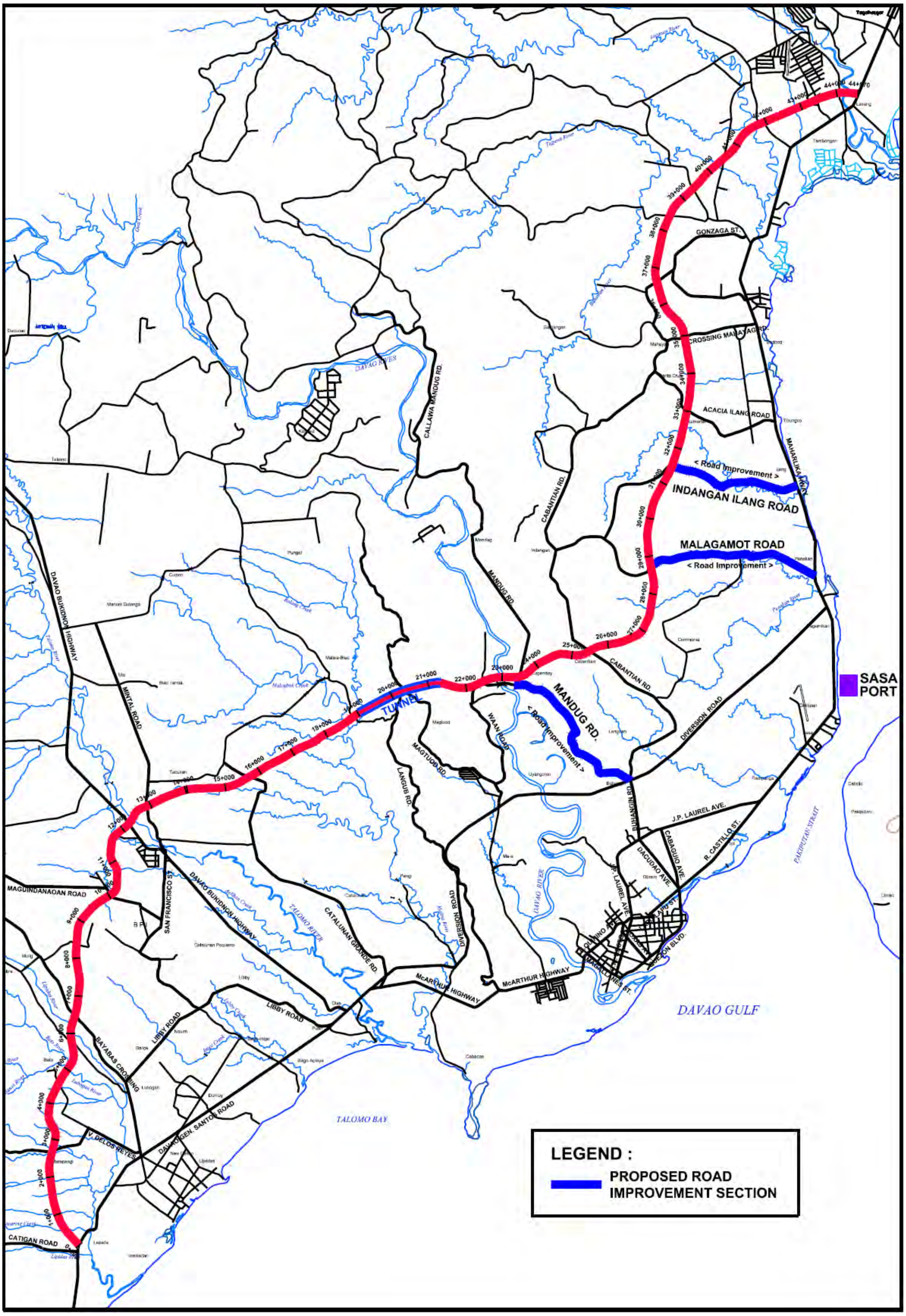


FIGURE 7.5-1 CONTAINER TRAFFIC FORECAST – DAVAO BAY (TOTAL)

With the above container traffic forecast for the Davao Bay at Sasa Port, the Davao City Bypass is undoubtedly necessary for easy movement of traffic in the area.

For easier access between Davao City Bypass and Sasa Port, the existing city road – Malagamot Road should be improved as shown in **Figure 7.5-2.**



Source: JICA Study Team

FIGURE 7.5-2 LOCATION MAP OF DAVAO CITY BYPASS AND SASA PORT AND THE PROPOSEC ROAD IMPROVEMENT OF EXISTING CITY ROAD

CHAPTER 8
REVIEW OF THE BUSINESS CASE STUDY

A Davao City Bypass was originally proposed by the JICA-assisted Master Plan Study on High Standard Highway Network Development Master Plan (HSH Master Plan), based on which DPWH undertook the Business Case Study (BCS) in 2013 to examine whether it can be implemented as a PPP scheme. The BCS concluded that the project as a PPP scheme is not feasible due to low financial viability and recommended that the project should be implemented as a conventional Government finance project. It also recommended that the Davao City Bypass should be first a non-toll 2-lane road.

8.1 ALIGNMENT

The proposed alignment is shown in **Figure 8.1-1**.

- Road Length : 41km
- Number of Lanes : 2 lanes
- Alignment recommended passes through the outskirt of Davao City urbanized area
- Alignment was discussed with Davao City Government and basically agreed
- No description in the Report on alternative alignment study

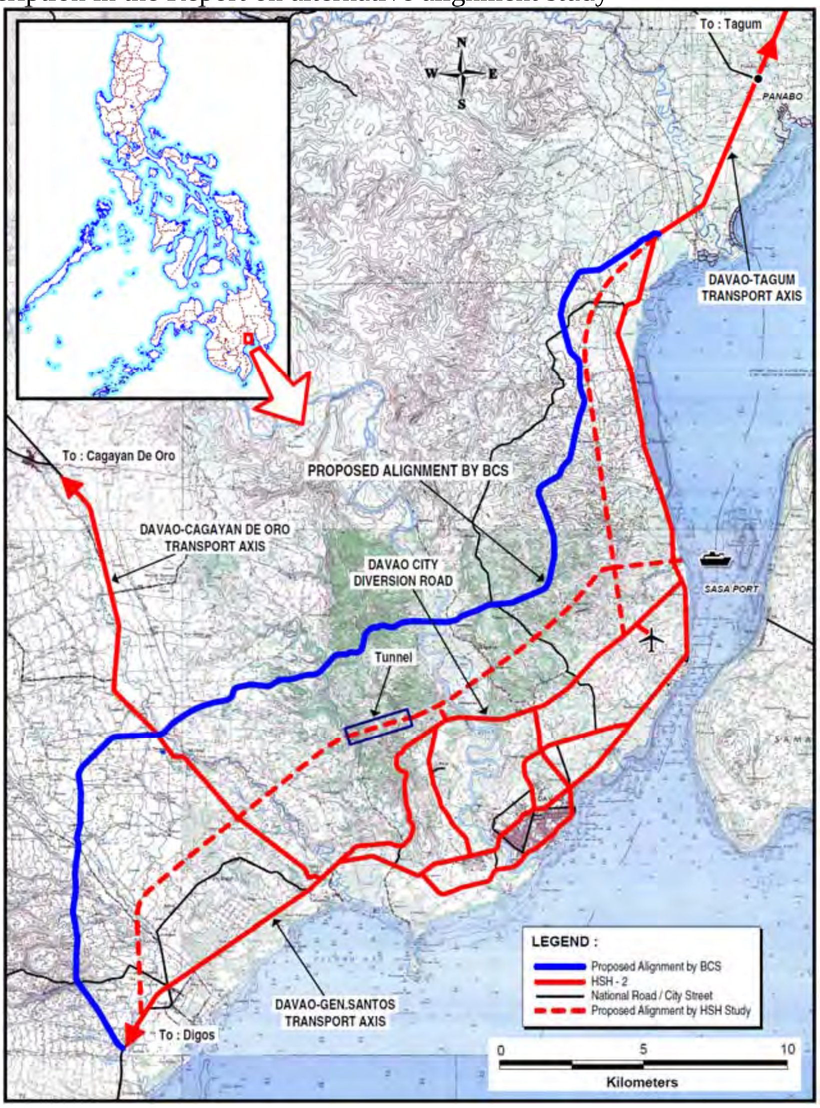


FIGURE 8.1-1 PROPOSED ALIGNMENT BY BCS

8.2 SCOPE OF THE PROJECT

Table 8.2-1 shows the scope of the Project and issues.

TABLE 8.2-1 REVIEW OF CONTENTS OF BCS

Items		Scope of the project by BCS	Issues
1) DESIGN SPEED AND CROSS SECTION ELEMENT	DESIGN SPEED	• Not described in the BCS report	• Assumed to be 60 – 80 km/hr dependent on the terrain.
	LANE WIDTH	• 2.40m	• Very sub-standard.
	SHOULDER WIDTH	• 1.50m	• Should be selected based on a terrain.
	ROW WIDTH	• 40m	• DPWH's standard is 30m for national roads. • ROW width will vary depending upon cut or embankment height.
2) ROAD SECTION	EMBANKMENT	• Embankment height more than 10m at the road center ⇒ L=720m • Highest embankment height ⇒23 m (90m ROW required.) (see **Figure 8.2-1**)	• Above result in severe natural destruction and high construction cost.
	CUT	• Cut height is more than 20m at the road center ⇒L= 3,670m • Highest cut height ⇒49m • Cut height is more than 30m ⇒7 locations (see **Figure 8.2-2**)	
3) TRAFFIC DEMAND FORECAST	DIVERTED TRAFFIC	• Estimated by section (2012) – South section : 2,570 veh/day – Central section : 5,289 veh/day – North section : 3,787 veh/day	• Methodology of traffic demand forecast is not explained well. • Traffic network analysis is needed. • Traffic demand forecast should be done based on future socio-economic framework.
	GENERATED TRAFFIC	• Assumed to be 25% of diverted traffic	
	FUTURE TRAFFIC	• Annual traffic growth rate was assumed. – Car : 6.2 ~ 6.5% per annum – Bus : 5.5 ~ 5.8% per annum – Truck : 4.5 ~ 4.8% per annum	
4) STRUCTURES	BRIDGE	• 22 bridges (less than 100m : 11 bridges, 100 ~ 220m : 11 bridges) total bridge length = 2,185m	• There are many cases, a valley (river) location is filled with embankment (no bridge or box culvert) based on JICA Study Team's review, 47 bridges and total bridge length=3,900m (see **Table 8.2-2**) • There are many cases where a proposed road elevation is lower than the bottom elevation of valley (see **Table 8.2-3**)
	FLYOVER BRIDGE	• 6 bridges (15 ~ 25 m in length)	
	OVERPASS BRIDGE FOR CROSSING ROADS	• 13 bridges	
	TUNNEL	• 1 tunnel, l = 2,020m	• Detailed study on selection of tunnel location was not done. • Tunnel section has some curves alignment. • Detailed geological studies needed.

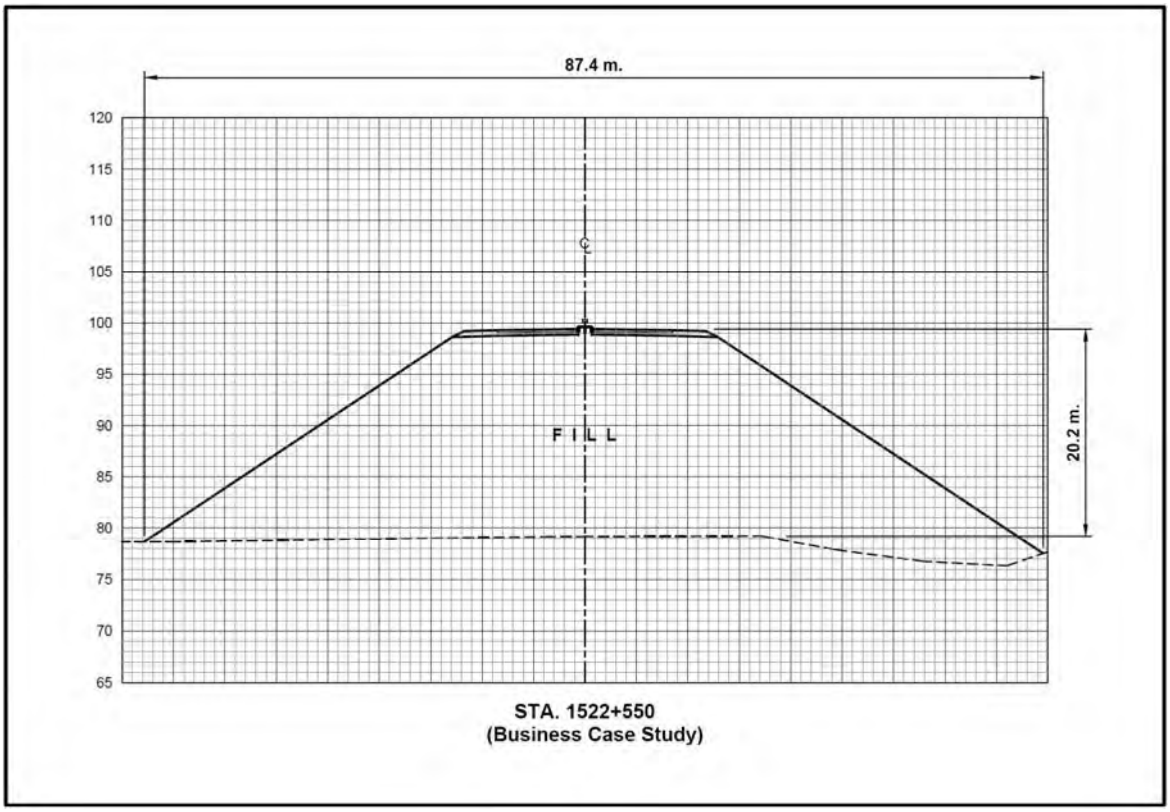


FIGURE 8.2-1 EXAMPLE OF EMBANKMENT CROSS SECTION BY BCS

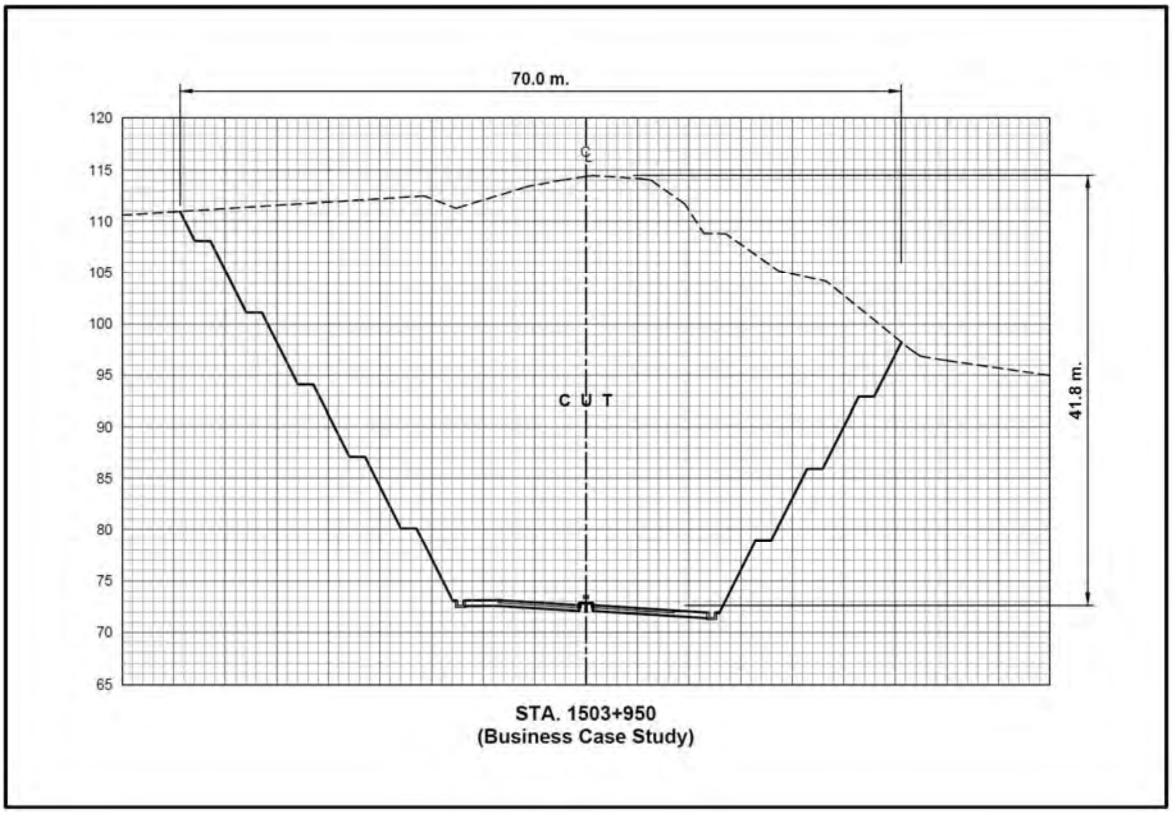


FIGURE 8.2-2 EXAMPLE OF CUT CROSS SECTION BY BCS

TABLE 8.2-2 (1/2) BRIDGE LIST PROPOSED BY BCS AND JICA TEAM

Station		Valley	River	Road	BCS Proposed			JICA Study Team Proposed			Remark
					Type of Bridge	Bridge Number	Proposed Bridge Length	Type of Bridge	Bridge Number	Proposed Bridge Length	
1483 +	250	O	O		RB	1	30m				
	350			O	FO	1	25m				
1484 +	375	O			RB	2	30m				
1485 +	200			O	FO	2	20m				
	550			O	FO	3	15m				DR
1486 +	375			O	OP	1					
1488 +	125			O	FO	4	20m				
	350	O			RB	3	60m				
1489 +	300	O	O					RB	23	40m	
	800	O	O					RB	24	45m	
	850			O	OP	2					DR
	900	O	O					BC	1	10m	
1490 +	200	O	O					RB	25	20m	
	550			O							DR
	950	O	O		RB	4	80m				
1491 +	50	O	O					RB	26	25m	
	200	O	O					RB	27	25m	
	400			O	OP	3					
1492 +	650			O				OP	14		DR
	850	O						BC	2	10m	
1493 +	100	O						RB	28	55m	
	500	O	O					RB	29	30m	
1494	400	O	O					RB	30	60m	
1495	150	O	O					RB	31	100m	
	650	O	O		RB	5	110m				
	875	O	O					RB	32	30m	
1496 +	0	O	O					RB	33	25m	
	200	O			RB	6	140m				
	500			O	IC	1					IC
	700	O	O					RB	34	30m	
	875	O	O					RB	35	25m	
1497	25			O	OP	4					
	250	O	O		RB	7	100m				
	650	O	O		RB	8	120m				
	850			O	OP	5					
	900	O	O					BC	3	5m	
1498 +	225	O	O					RB	36	30m	
	650	O						RB	37	90m	
1499	50	O	O					RB	38	40m	
	650			O	OP	6					
1500 +	0	O	O					RB	39	50m	
	100	O	O					RB	40	15m	
	650	O	O		RB	9	100m				
1501 +	300			O	IC	2					IC,DR
	650			O				BC	4	10m	DR
	950			O				BC	5	10m	DR
1502 +	100	O	O		RB	10	80m	RB	10	200m	Davao Rv
1503 +	450	O	O		RB	11	90m				

Source: JICA Study Team

TABLE 8.2-2 (2/2) BRIDGE LIST PROPOSED BY BCS AND JICA TEAM

Station	Valley	River	Road	BCS Proposed: Type of Bridge	BCS Proposed: Bridge Number	BCS Proposed: Proposed Bridge Length	JICA Study Team Proposed: Type of Bridge	JICA Study Team Proposed: Bridge Number	JICA Study Team Proposed: Proposed Bridge Length	Remark
1507 + 50	O	O					RB	41	110m	
1508 + 100	O	O		RB	12	120m	RB	12	180m	
800			O	OP	6					DR
1509 + 100	O						RB	42	80m	
1510 + 200			O	OP	7					
550	O	O					RB	43	25m	
775			O	OP	8					
900	O	O					BC	6	10m	
1511 + 250		O					BC	7	10m	
650	O						RB	44	75m	
1512 + 850			O	OP	9					
1513 + 200	O	O		RB	13	90m				
450			O	OP	10					Davao - Bukinodon Rd.+Canal
1514 + 0		O					BC	8	10m	
1515 425			O	OP	11					DR
1516 300	O	O		RB	14	60m				
950			O	FO	3	20m				DR
1518 200			O	FO	4	25m				DR
1519 125			O				BC	9	10m	DR
200		O		RB	15	30m				
250		O	O	OP	12					DR+Canal
650	O	?					BC	10	10m	
1520 + 0	O	O		RB	16	115m				
750	O	O		RB	17	105m				
950	O	O					BC	11	10m	
1521 750	O	O		RB	18	220m				
1522 250	O						RB	45	450m	
1523 650	O	O		RB	19	150m				
825	O						BC	12	10m	
1524 300	O	O		RB	20	160m				
1525 500	O						RB	46	40m	
800			O	OP	13					
1526 100	O	O		RB	21	70m				
600	O	O		RB	22	80m				
800	O	O					RB	47	20m	
						1125m			560m	

BCS Type	BCS Number	BCS Length	JICA Type	JICA Number	JICA Length
RB	22	2185m	RB	47	3900m
FO+IC	6	80m	FO+IC	6	80m
OP	13		OP	14	
			BC	12	115m

Abbreviated Name
RB:River Bridge
FO:Fly Over
OP:Over Pass
BC:Box Culvert

DR:District Road

Source: JICA Study Team

TABLE 8.2-3 LOCATIONS OF PROPOSED PROFILE IS LOWER THAN WATERWAY BED

No.	Station			Finished Grade	Original Grade	Difference	
1	1489	+	750	79.6	84.3	−4.7	m
2	1490	+	200	87.5	85.0	2.5	m
3	1491	+	800	55.7	68.5	−12.8	m
4	1494	+	650	57.2	62.2	−5.0	m
5	1495	+	400	59.2	70.2	−11.0	m
6	1497	+	775	42.4	45.8	−3.4	m
7	1497	+	900	50.4	49.2	1.2	m
8	1500	+	300	62.7	65.5	−2.8	m
9	1504	+	0	63.9	63.5	0.4	m
10	1507	+	275	35.4	55.5	−20.1	m
11	1513	+	450	126.0	126.6	−0.6	m
12	1520	+	950	124.3	122.2	2.1	m
13	1524	+	0	80.5	101.2	−20.7	m
14	1524	+	550	76.6	85.4	−8.8	m

8.3 PROJECT COST

(CONFIDENTIAL)

CHAPTER 9
ALIGNMENT SELECTION OF DAVAO CITY BYPASS

9.1 PROCEDURE OF ALIGNMENT STUDY

The procedure of alignment study is shown in **Figure 9.1-1**.

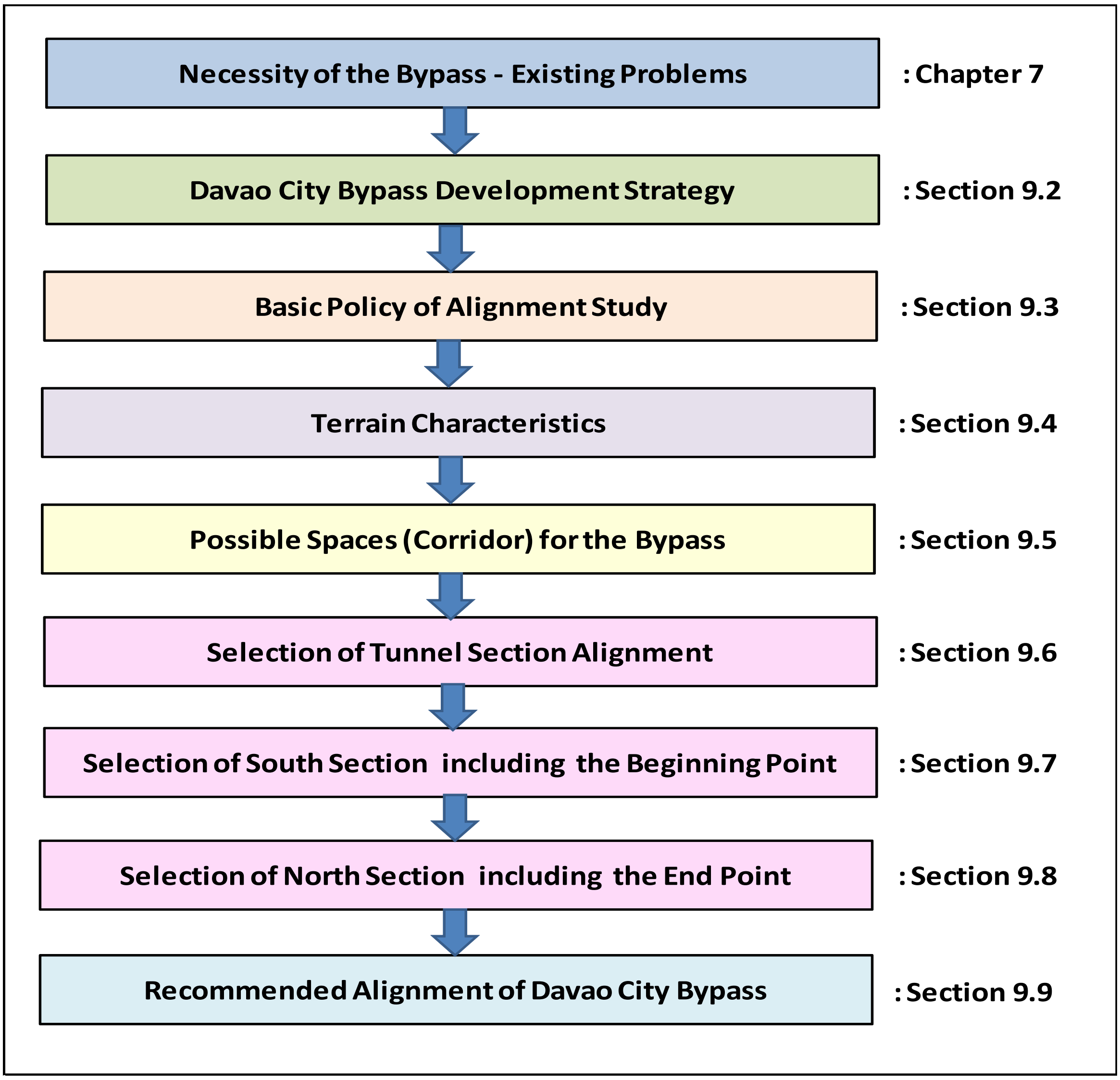


FIGURE 9.1-1 PROCEDURE OF ALIGNMENT STUDY

9.2 DAVAO CITY BYPASS DEVELOPMENT STRATEGY

The Davao City Bypass development strategy was proposed as follows:

- Bypass should be so planned that through traffic can be diverted to the Bypass. (Road standards should be as high as possible and a bypass length should be as shorter as possible.)
- Bypass should also be so planned that the Urban Center related traffic from/to surrounding areas can be diverted to the Bypass. (Existing roads which intersect with the Bypass should be improved.)
- Bypass should be so planned that it will guide sound urbanization of inland areas of the city.
- Bypass should be planned to provide easier access to other transport facilities, such as an airport and sea ports.

9.3 BASIC POLICY OF ALIGNMENT STUDY

Basic policies for selecting the optimum alignment were established as follows:

- Since the alignment selected by BCS has been consulted with Davao City Government, it will be a basis for alignment study.
- Tunnel section will be selected in due consideration of topographic and geological conditions.
- Existing and planned development should not be affected as much as possible.
- Alignment will be so selected to minimize relocation of people.
- How to connect with intersecting roads will be carefully studied.
- Connection with the Davao International Airport, Sasa Port, private ports, etc. will be carefully considered.

9.4 TERRAIN CHARACTERISTICS

Terrain characteristics in terms of ground elevation of the Project Area is shown in **Figure 9.4-1**.

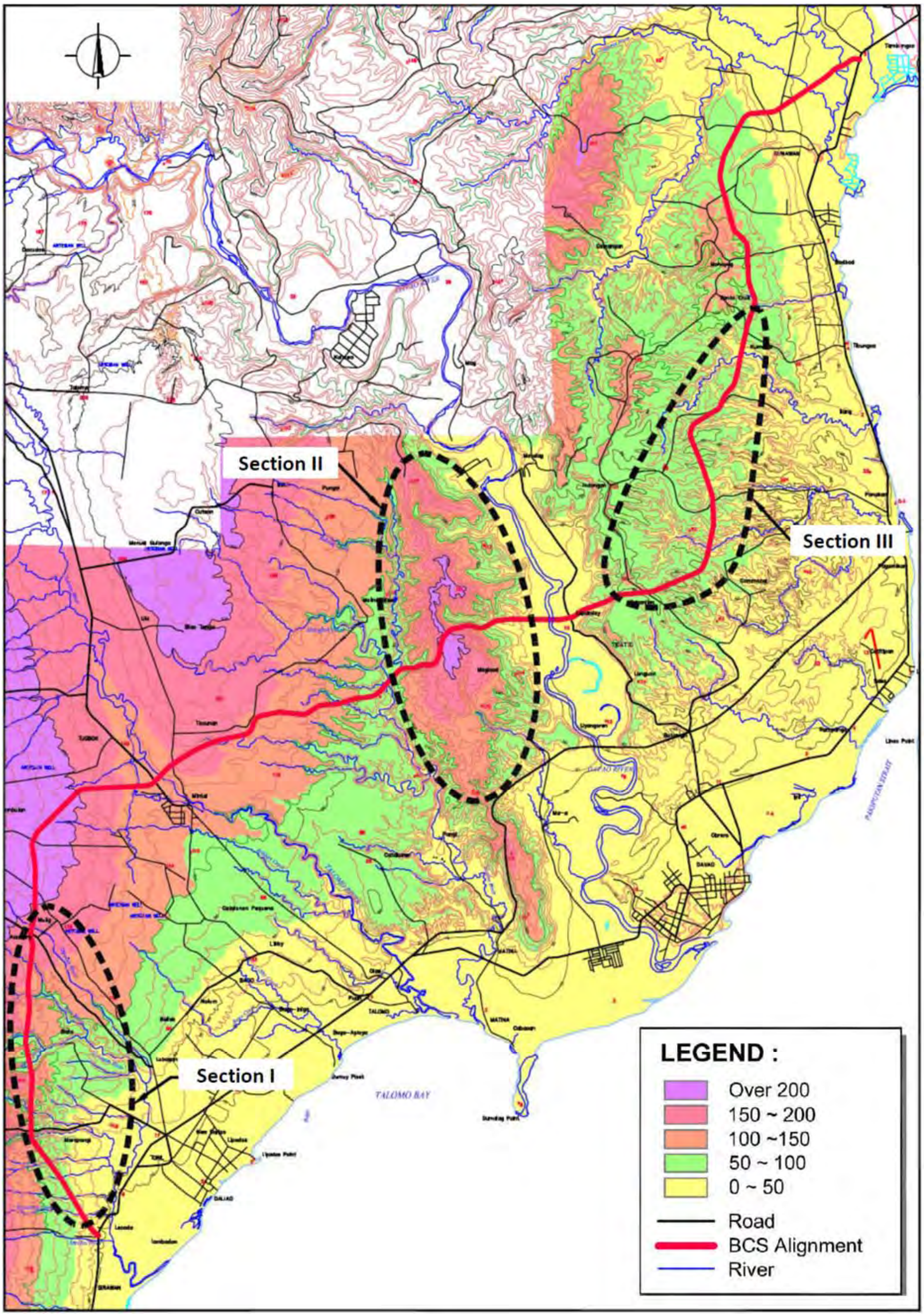
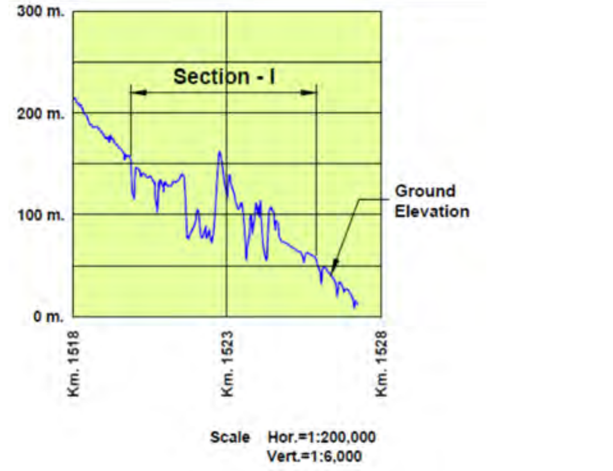


FIGURE 9.4-1 TERRAIN CHARACTERISTICS

<table>
<tr>
<td>
</td>
<td><u>Section-I: South Section</u>

The topography is quite complex and undulating.
Located at the foot of Mt. Apo, of which slope has been eroded/scoured and numerous rivers/valleys were formed.
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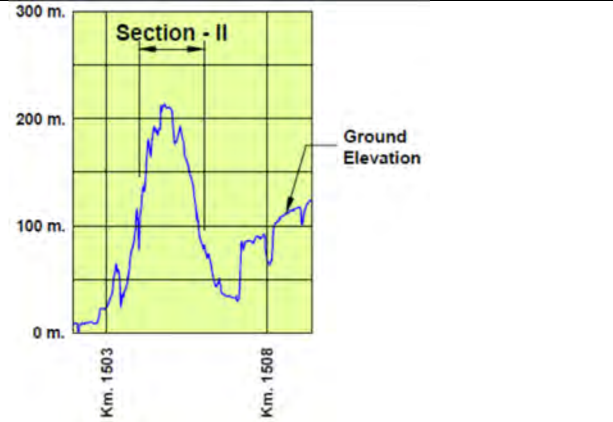
<tr>
<td>
</td>
<td><u>Section-II: Tunnel Section</u>

Elevation varies from 15m to 215m within 2km section, ground inclination varies from about 10% to 12%.
A tunnel is needed.
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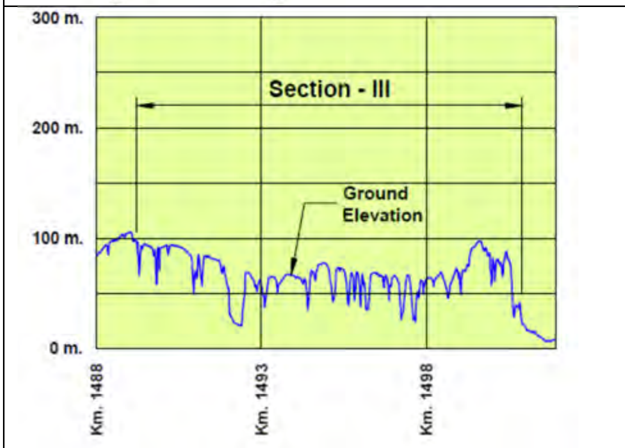
<td>
</td>
<td><u>Section-III: North Section</u>

The topography is quite complex and undulating.
The Plateau was eroded/scoured and numerous rivers/valleys were formed.
</td>
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</table>

9.5 POSSIBLE SPACES (CORRIDOR) FOR THE BYPASS

Urban development is progressing mainly along the following national roads;

- Davao - General Santos Road in the south
- Davao - Bukidnon Road in the west
- Diversion Road in the center
- Daang Maharlika in the north

Due to existing development along the above national roads, the space where the bypass can pass through (or the bypass corridor) is rather limited.

Based on the latest satellite photos, the possible space (corridor) for the bypass for the above four (4) areas was identified (see **Figure 9.5-1**).

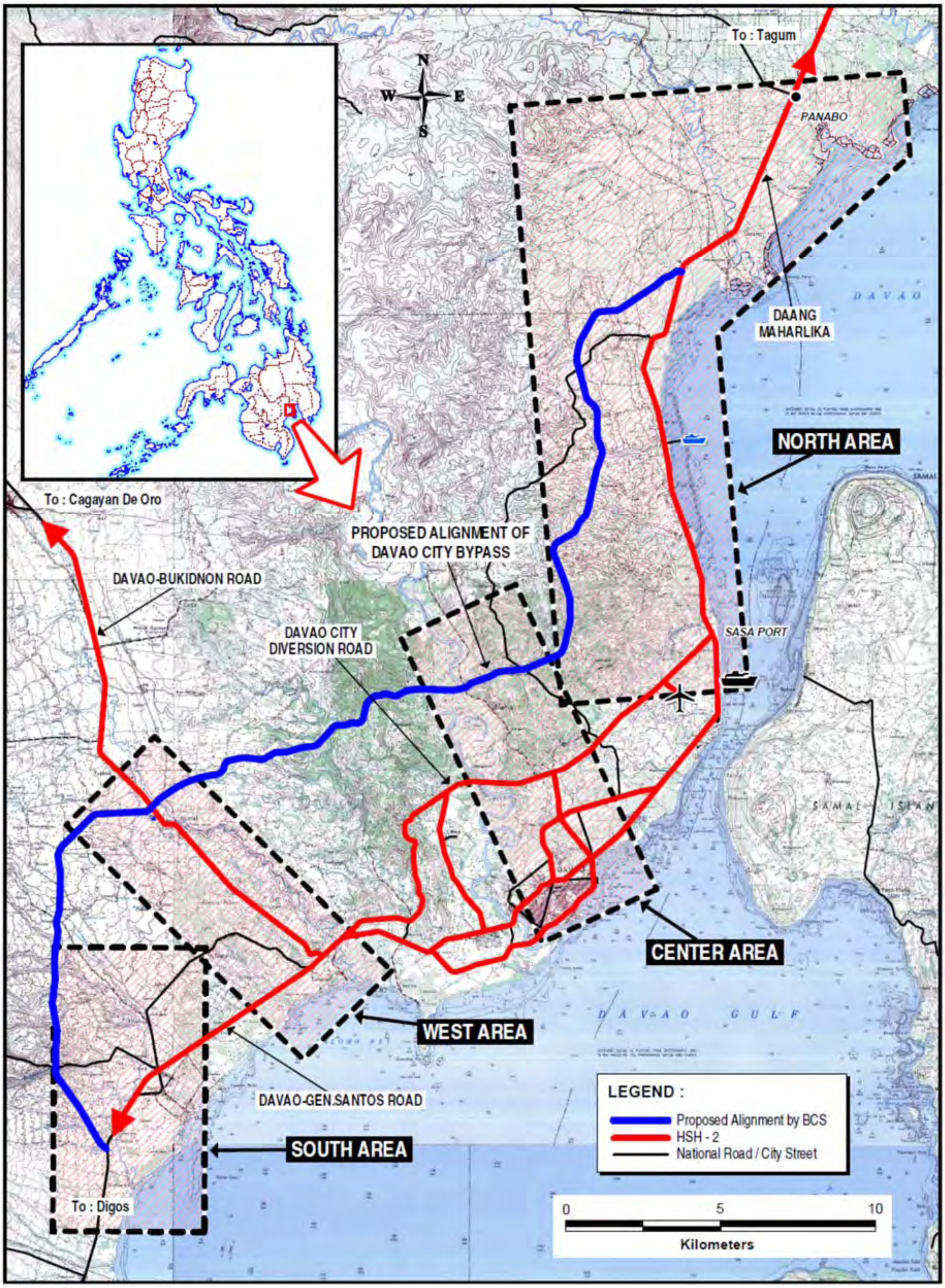


FIGURE 9.5-1 AREAS FOR STUDY ON POSSIBLE SPACE (CORRIDOR) FOR THE BYPASS

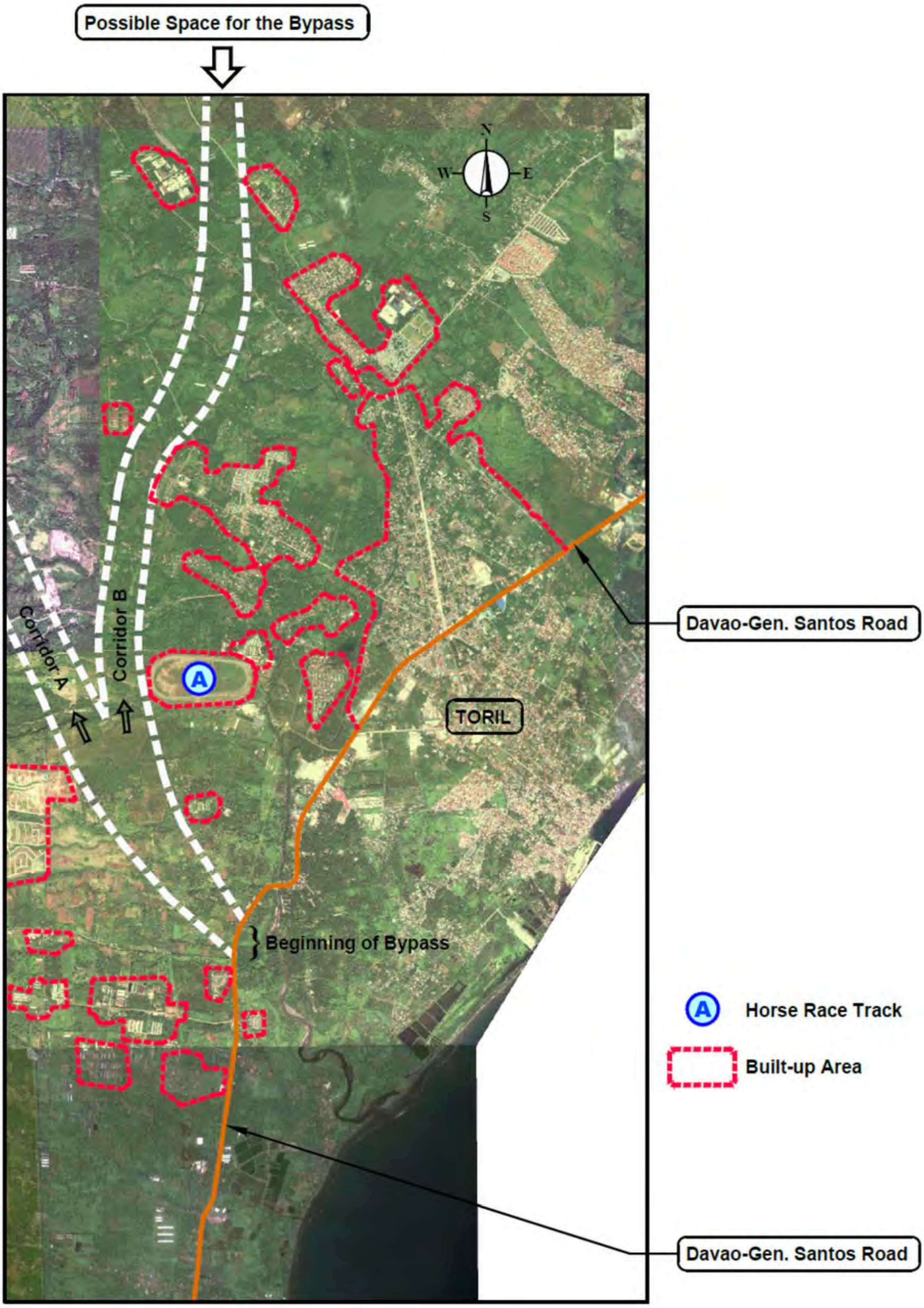


FIGURE 9.5-2 POSSIBLE SPACE FOR THE BYPASS IN SOUTH AREA

(1) Possible Space for the Bypass in the South Area

In the south area, urban development is progressing along Davao – General Santos Road (see **Figure 9.5-2**).

Beginning of the Bypass: Since Toril is one of the busiest urban areas in Davao City and there are no large urban areas in the south of Toril, the Bypass should start at the south of Toril.

Possible Space for the Bypass: There are two (2) possible space (corridor) for the Bypass. Corridor A is the space proposed by the Business Case Study which passes through the in-land area along the slope of Mt. Apo and the terrain is quite complex (or undulating). Corridor A passes through far from the urban areas. Whereas Corridor B passes through the open areas closer to the urban center with the shorter road length than Corridor A. Alternative alignments along Corridors A and B are studied for detailed comparison of advantages of alignments.

(2) Possible Space for the Bypass in the West Area

In the west area, road sides along Davao-Bukidnon Road is highly urbanized as shown in **Figure 9.5-3**, there is no space for the Bypass to pass through up to Mintal. Possible space for the Bypass is only located at the north of Mintal.

(3) Possible Space for the Bypass near Davao River in the Center Area

Possible space for the Bypass near Davao River in the Center Area is shown in **Figure 9.5-4.** There is narrow space for the Bypass near the existing Waan Bridge.

(4) Possible Space for the Bypass in the North Area

1) Traffic Condition Along Daang Maharlika

Urbanization and industrial estates are progressing along Daang Maharlika along which relatively high concentrations of commercial activities are observed at Panacan, Tibungco, and Bunawan (see **Figure 9.5-5**). In these areas, through traffic is highly disturbed by parked vehicles on the road and local traffic of tricycles and jeepneys.

Traffic Condition at Panacan

Traffic Condition at Tibungco

Traffic condition at Licanan and Lasang is better than Panacan, Tibungco and Bunawan.

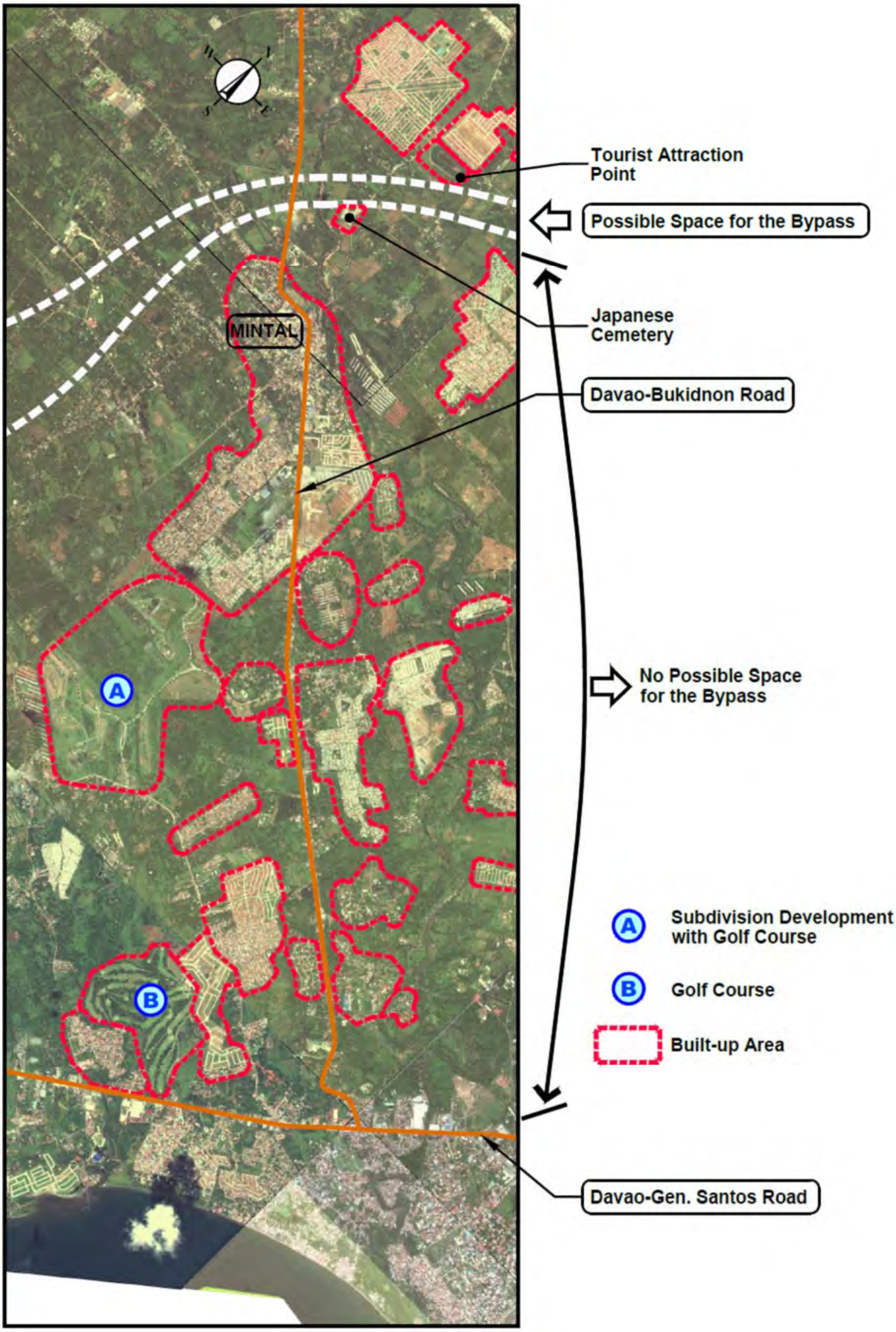


FIGURE 9.5-3 POSSIBLE SPACE FOR THE BYPASS ALONG DAVAO-BUKIDNON ROAD (WEST AREA)

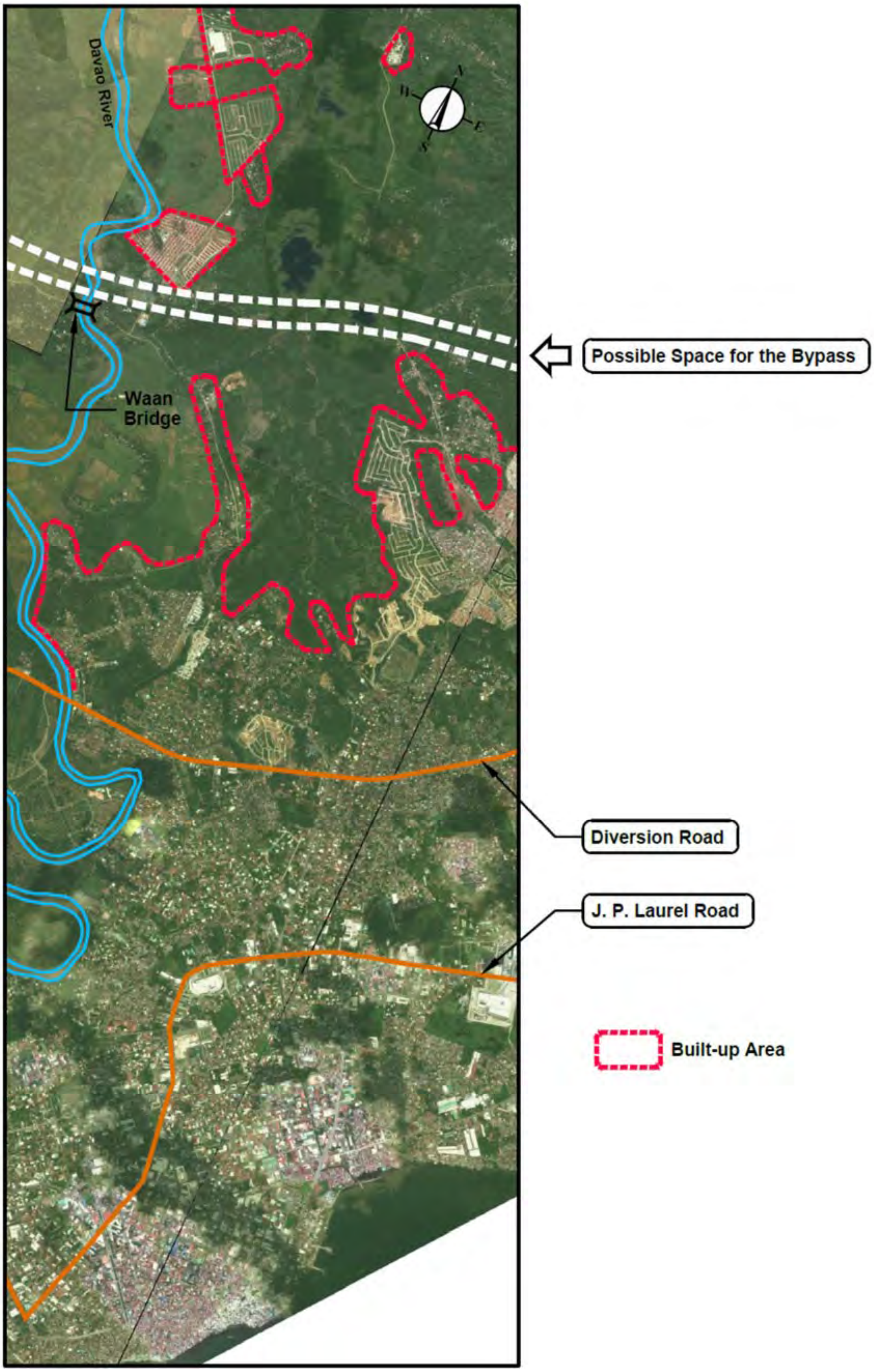


FIGURE 9.5-4 POSSIBLE SPACE FOR THE BYPASS NEAR DAVAO RIVER (CENTER AREA)

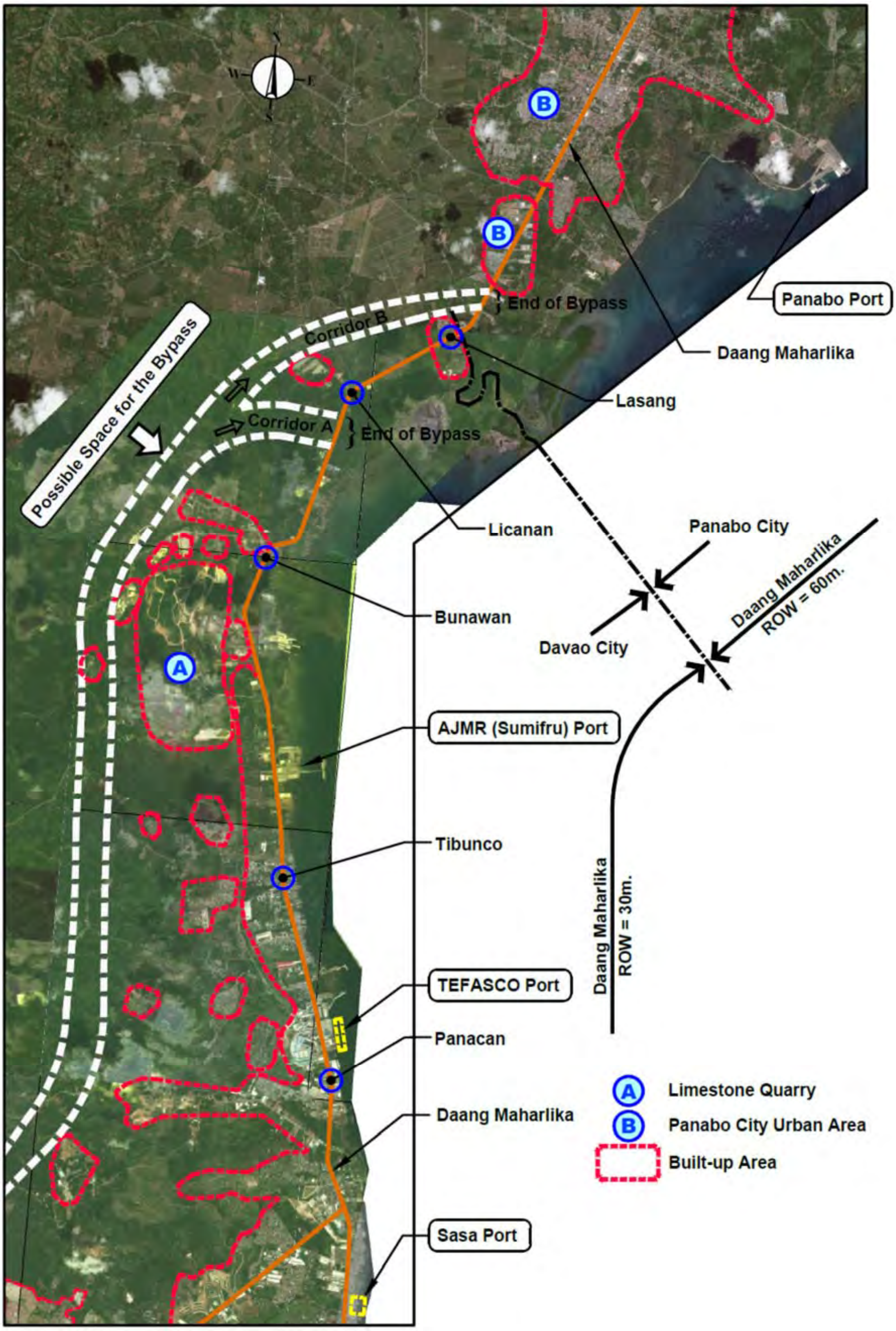


FIGURE 9.5-5 POSSIBLE SPACE FOR THE BYPASS IN NORTH AREA

2) Ports in the North Area

There are one (1) public port (Sasa Port) and three (3) private ports (TEFASCO Port, AJMR (Sumifro) Port and Panabo Port).

The Bypass should be so planned that accessibility to these ports will be improved to support economic development. Some examples how these ports are used by manufacturing companies and agro-industry companies were presented in Chapter 7.

3) Possible Space for the Bypass

In the north area, possible space for the Bypass is available almost in parallel with Daang Maharlika. Available space is found at 2 to 3 km west of Daang Maharlika as shown in **Figure 9.5-5**. There are two options (Corridor-A and Corridor-B) for the end point of the Bypass.

Corridor-A:	Ends at slightly south of Licanan
Corridor-B:	ends at southern end area of Panabo City

Two options are studied in Section 9.8.

9.6 SELECTION OF CENTER SECTION ALIGNMENT

The Center Section includes a tunnel. Firstly, tunnel alternative alignments were studied, and then the Center Section alignments which include approach sections to a tunnel were evaluated.

9.6.1 Topographical Feature

The topographical feature of a tunnel section is shown in **Figure 9.6-1**, and summarized as follows;

- Elevation varies from 15m to 215m within the length of about 1.5km to 2.0km.
- Ground surface gradient ranges from 10% to 15%.
- The mountain is surrounded by two rivers; Davao River at the east side and Matina River at the west side,
- The mountain has been eroded and many valleys are formed.

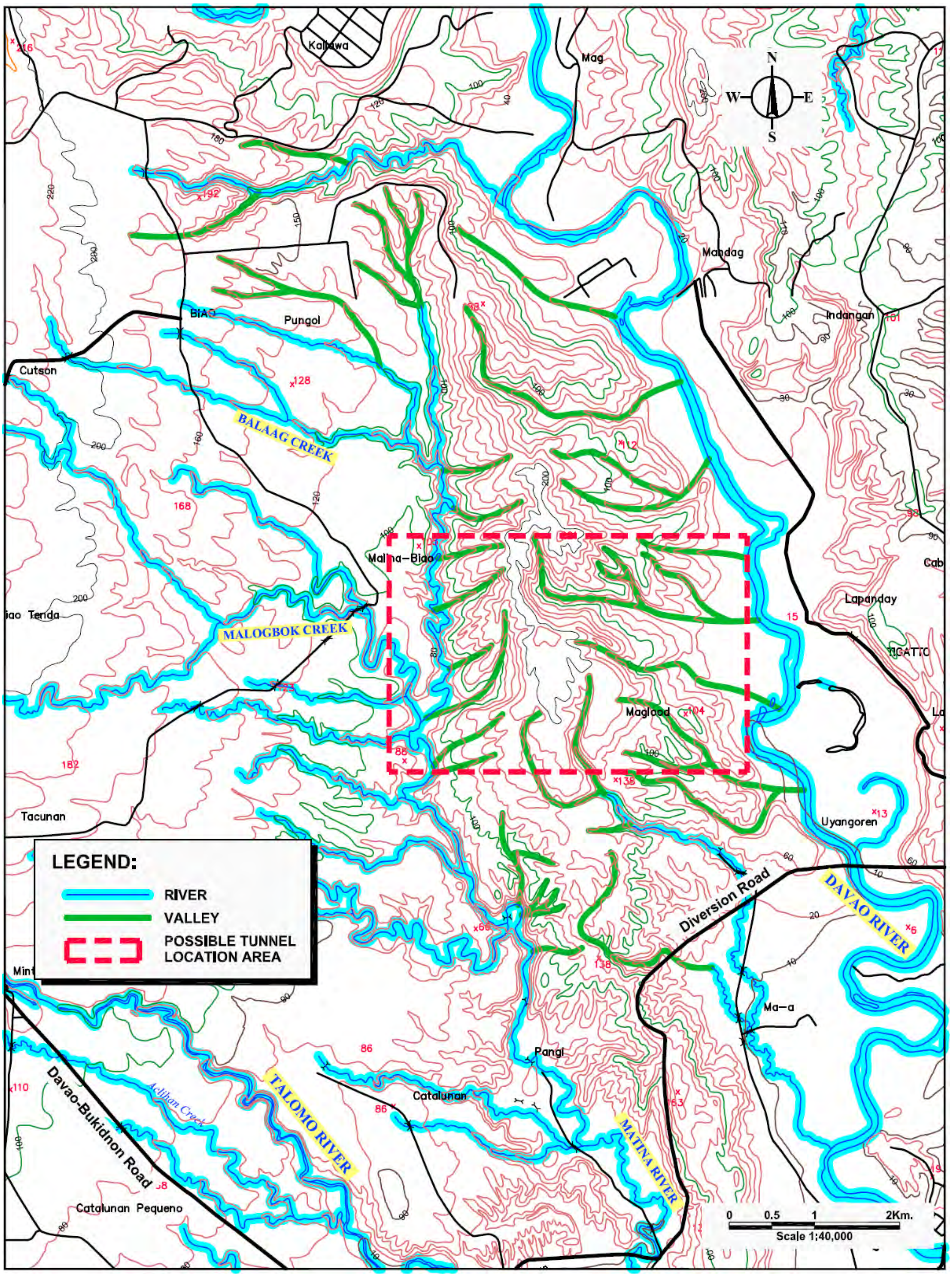


FIGURE 9.6-1 TOPOGRAPHICAL FEATURE

9.6.2 Geological Features

The geological profile is shown in **Figure 9.6-2**. The subject mountain is made of Masuhi Formation. Masuhi formation is composed of sandstone, mudstone, and conglomerate of the Tertiary Miocene Pliocen. It is expected that tunnel excavation can be done without blasting.

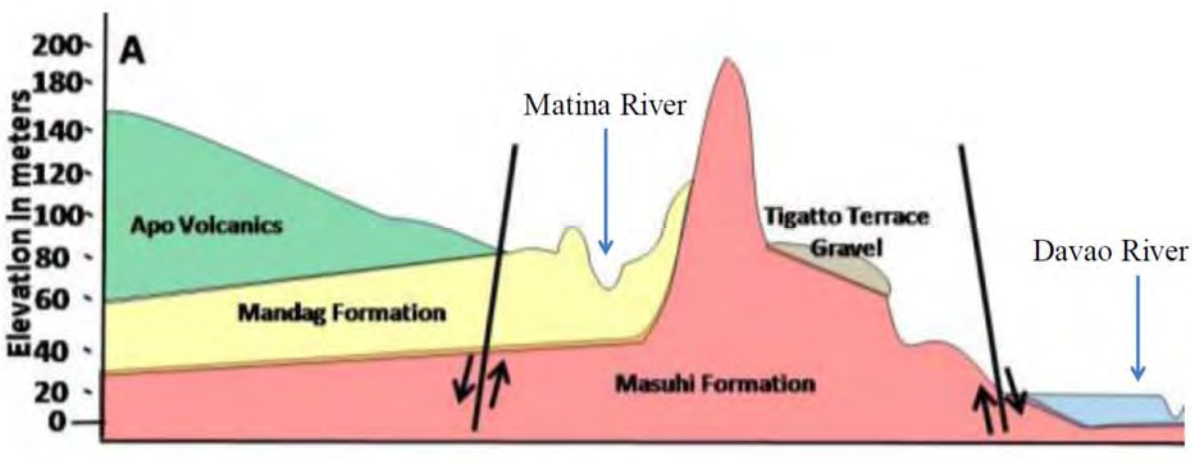


FIGURE 9.6-2 GEOLOGICAL PROFILE

9.6.3 Topography v.s. Tunnel Centerline

A tunnel centerline must be selected in due consideration of easier construction and operation/maintenance. In the selection of tunnel centerline, it is quite important to analyze topographical characteristics of tunnel corridor. **Figure 9.6-3** shows the location of the centerline against topography.

Type-1: Tunnel Centerline is Perpendicular to Mountain Slope

A tunnel centerline is selected almost perpendicular to the mountain slope. This is the most ideal type for a tunnel on the condition that the mountain slope is not subjected to a landslide.

When a tunnel portal is selected at the middle of slope, an access road to a tunnel portal during construction is needed.

Type-2: Tunnel Centerline is Diagonal to Mountain Slope

A tunnel centerline is selected diagonal to the mountain slope. When an inclination of rock layers is the same as that of a mountain slope, unsymmetrical earth pressure is expected, thus, this type of tunnel location should be avoided as much as possible.

Type-3: Tunnel Centerline Passes at Valley

Valley is usually subjected to water flow, debris flow, etc., a tunnel location should not be selected at this type of location.

Type-4: Tunnel Centerline Passes Under Ridge of Mountain

When bedrocks are found and thickness of weathered rock is thin, no problem is expected. There are some cases that talus deposit is quite thick due to past collapse of a mountain, detailed geological analysis is needed.

Type-5: Tunnel Centerline is almost Parallel to Mountain Slope

There are cases that earth thickness over a tunnel drastically changes at one side of a tunnel and unsymmetrical earth pressure is subjected to a tunnel cross section, this type of location should be avoided as much as possible.

In the selection of tunnel location, topographical conditions are evaluated and various tunnel locations are selected for evaluation.

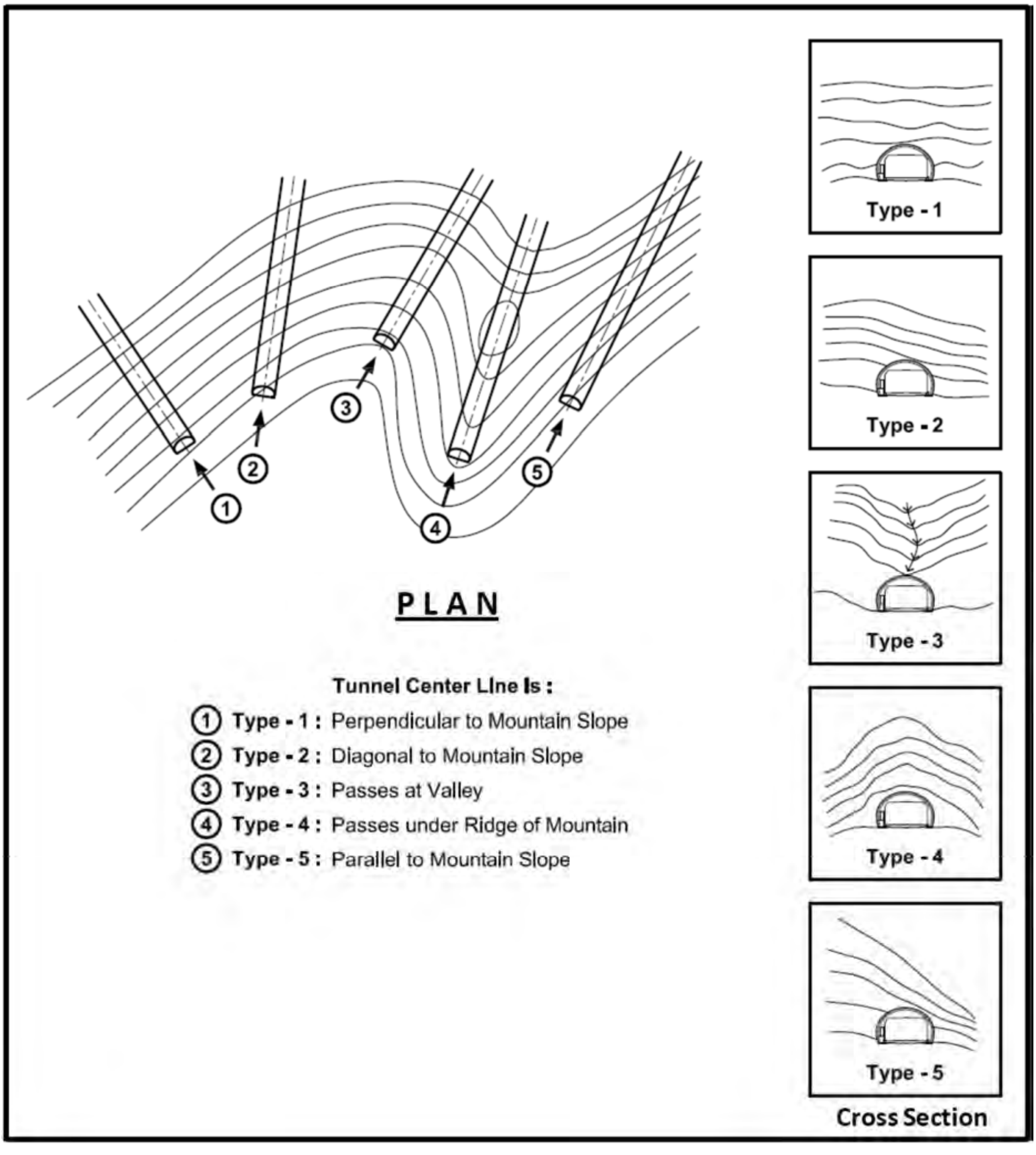


FIGURE 9.6-3 TOPOGRAPHY V.S. CENTERLINE OF TUNNEL

9.6.4 Alternatives of Tunnel Alignment

(1) Alternative Alignments and Pre-screening

The following three (3) groups of alternative alignments were compared:

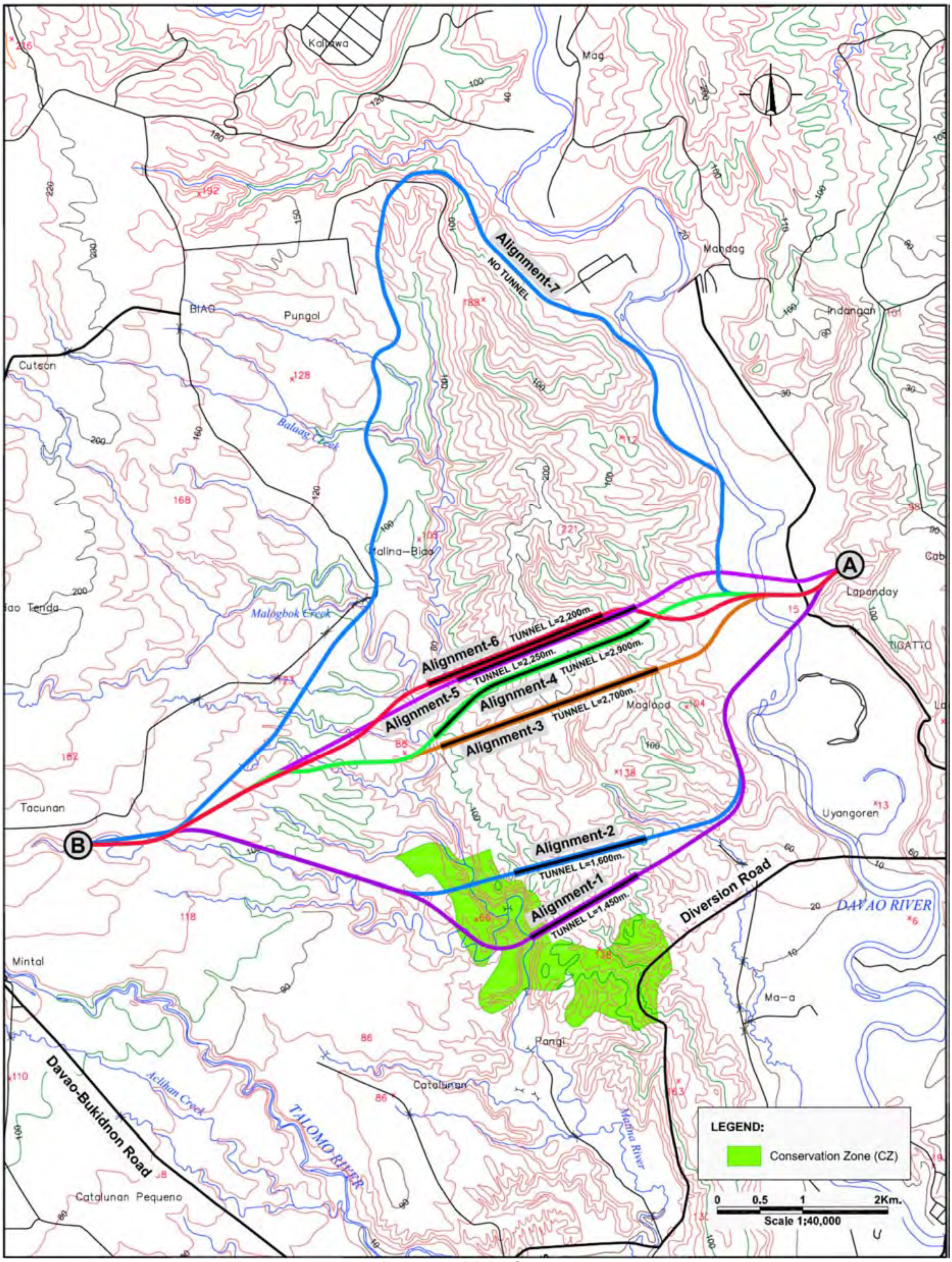
Group-1	Alternative which requires a shorter tunnel length. Topographic conditions are evaluated and two (2) alternative alignments are selected.
Group-2	Alternative which requires a shorter road length and attracts more traffic, since the bypass should attract as many traffic as possible to reduce traffic problems in the Urban Center. Four (4) alternatives are selected.
Group-3	Alternative which does not require a tunnel. This alternative requires a long detour to climb up/down the mountain. This group intends to reduce construction cost; however, function of a bypass is sacrificed. A few traffic is expected to divert to a bypass of this group. One (1) alternative is selected.

A total of seven (7) alternatives were selected and summarized in **Table 9.6-1** as shown in **Figure 9.6-4**.

TABLE 9.6-1 ALTERNATIVES OF TUNNEL SECTION

Group	Alternative	Concept	Road Length between A & B	Tunnel Length	Attracted Traffic (2013 OD) (veh/day)	Pre-screening
1	**1**	• Reduce tunnel length	12.0km (+2.1km)	1,450m	3,500	X
	2	• Reduce tunnel length	11.4km (+1.5km)	1,600m	3,600	X
2	**3**	• Make road length shorter to attract traffic on bypass	9.9km (+0.1km)	2,700m	5,300	○
	4	• Make road length shorter to attract traffic on bypass	9.9km (+0.1km)	2,900m	5,300	○
	5	• Make road length shorter to attract traffic on bypass	9.8km (+0.0km)	2,250m	5,300	○
	6	• Make road length shorter to attract traffic on bypass	9.9km (+0.1km)	2,200m	5,300	○
3	**7**	• Alignment which does not require a tunnel	18.6km (+8.8km)	0 (No Tunnel)	1,600	○

Source: JICA Study Team



Source: JICA Study Team

FIGURE 9.6-4 ALTERNATIVE ALIGNMENTS OF TUNNEL SECTION

Pre-screening

Two (2) alternatives, namely Alternatives -1and -2, are screened out from the alternatives due to the following reasons;

Alternatives-1 and -2

- Although tunnel length becomes shorter than Group-2 alternatives, road length becomes longer by 2.1km (Alternative-1) and 1.5km (Alternative-2).
- Due to longer road length or travel length, attract less traffic on the bypass than Group-2 alternatives, which means less contribution for reduction of traffic problems in the urban center.
- Approach road section to a west tunnel portal passes through **Conservation Zone**, thus it is not favorable for road construction.

(2) Comparison of Alternatives which Passed Pre-screening

Five (5) alternatives, namely Alternatives-3, -4, -5,-6, and -7 passed the pre-screening, which are subjected to the detailed comparison. Profiles of tunnel section of four (4) alternatives are shown in **Figure 9.6-5**. Comparison of tunnels is shown in **Table 9.6-2**.

TABLE 9.6-2 COMPARISON OF TUNNEL PORTION

Alt.	Tunnel Length (m)	Elevation of Portal		Vertical Grade of Tunnel Approach		Issues	Tunnel Construction Cost (Million Php)
		West side	East side	West side	East side		
3	2,700m (+500m)	70.0	49.5	3.4 %	3.7 %	• 500m longer than Alt.6. • East approach requires high embankment or a viaduct.	
4	2,900m (+700m)	65.0	58.2	4.6 %	5.0 %	• Longest tunnel required. • Tunnel has to pass under a deep valley, special construction method for 200m section required.	
5	2,250m (+50m)	60.0	57.5	3.1 %	2.5 %	• 50m longer than Alt.6. • At west side of west portal, low ground area for 500m in length exists where bridges and high embankment is needed.	
6	2,200m (0)	60.0	59.0	3.8 %	4.0 %	• Shortest tunnel • East approach needs high embankment or viaduct	
7	No Tunnel						

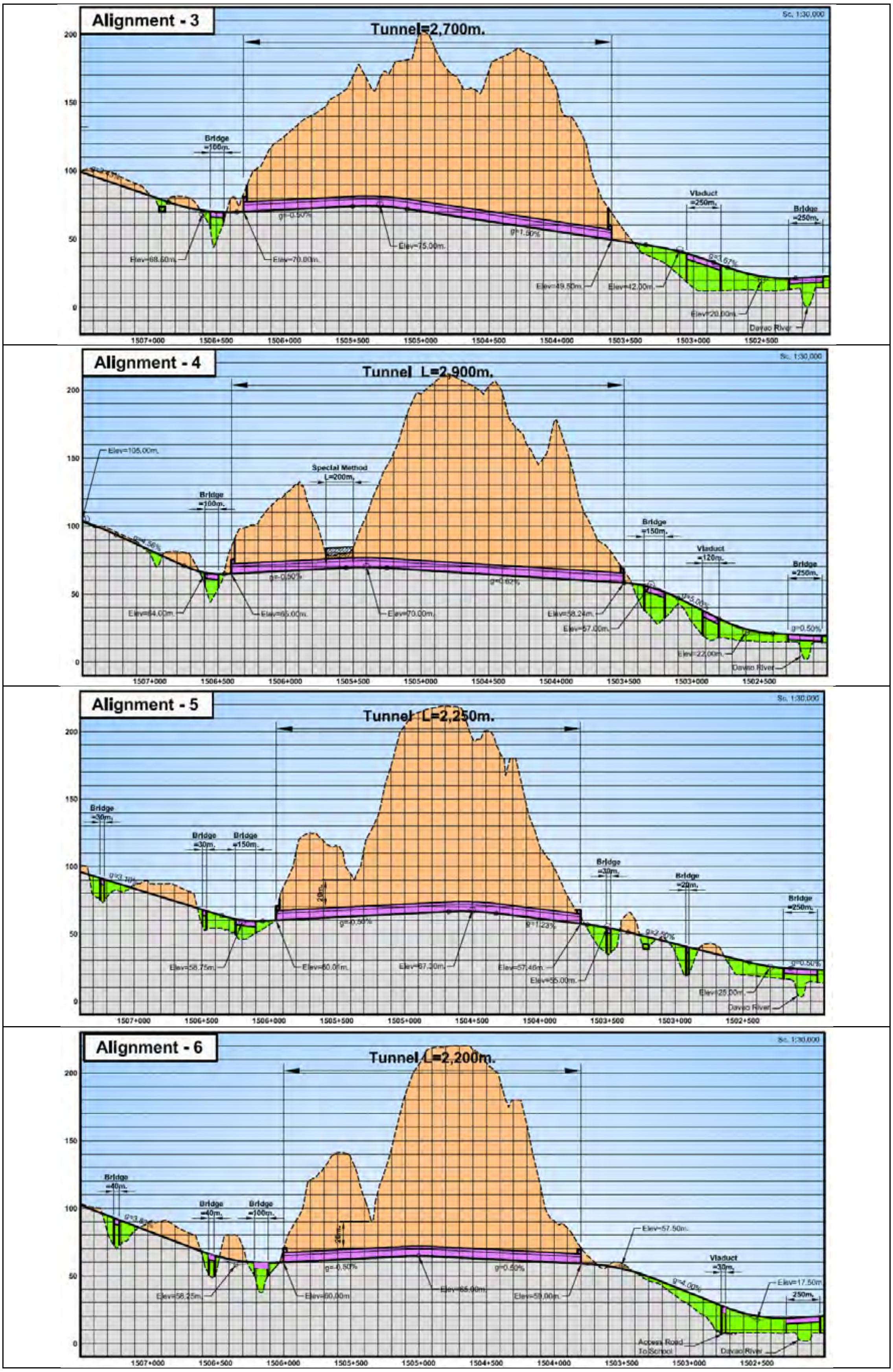


FIGURE 9.6-5 PROFILE OF TUNNEL SECTION

9.6.5 Evaluation of Alternatives of Center Section as a Whole

Alternatives based on a tunnel alignment are shown in **Figure 9.6-6**.

(1) Evaluation Items

The following evaluation criteria were established:

Evaluation Items

1) Traffic Volume Attracted on to the Bypass

When attracted traffic is higher, the better.

2) Project Cost

Construction cost and ROW acquisition cost was estimated. The lesser the cost, the better. Construction cost consists of pavement cost, cut and embankment cost, bridge cost and slope protection cost. Slope protection cost is estimated based on high cut section length.

3) Connection with the Urbanized Area

The bypass should have better connection with the urbanized area. The shorter access distance from the bypass to the urbanized area, the better.

4) Impact on Natural Environment

Five (5) factors were considered.

4-1) Cut Slope Erosion: When a slope is cut, it is subjected to erosion, thus lesser slope cutting in terms of cut volume (m^3), the better.

4-2) Tree Cutting (Less Greenery): When more trees are cut, it is subjected to loss of absorption capacity of CO_2. Thus, the lesser tree cutting, the better.

4-3) Flood: When it rains heavily in this area, flood may occur along the river. Though bridge construction will not affect the impact of flood prone area, the lesser river crossing, the better.

4-4) Earthquake: When high embankment is constructed, it is subjected to high probability of road collapses, thus lesser length of high embankment ($H \geq 5m$), the better.

4-5) Biology: General condition of the proposed route is passing through developed area. Some areas are forest, however, mostly are secondary forest. Mt. Apo is 10km east of the project area, which is home to one of the world's largest eagle: the critically endangered monkey-eating Philippine Eagle is much far from the proposed route, far is better.

5) Social Impact

Two (2) factors were considered.

5-1) Number of Affected Houses/Buildings: When more houses/buildings are affected and more residents will be force to relocate, the more impacts on their lives and livelihood. Thus, the lesser number of houses/buildings affected, the better.

5-2) Affected Agricultural Land: Most of the areas long the Project are agricultural plantation area, such as coconuts, bananas and mangoes. Many people along the Project area relies their livelihood on agricultural plantation. When more agricultural lands are taken by the project, the more people's lives and livelihood are affected. Impact on agricultural plantation was measured by a road length (in km.) which passes through agricultural land.

6) Construction Period

Construction period was estimated. The shorter construction period, the better.

7) Road Network

Additional new link is better to strengthen the road network.

8) Impact of Residential Development

Bypass should support for the future residential area development. The nearer development area, the better.

9) O & M Cost

Operation and Maintenance (O&M) Cost was estimated. The lesser the O&M Cost, the better.

10) Other Aspects

Other aspects were evaluated by segregation of positive impacts and negative impacts.

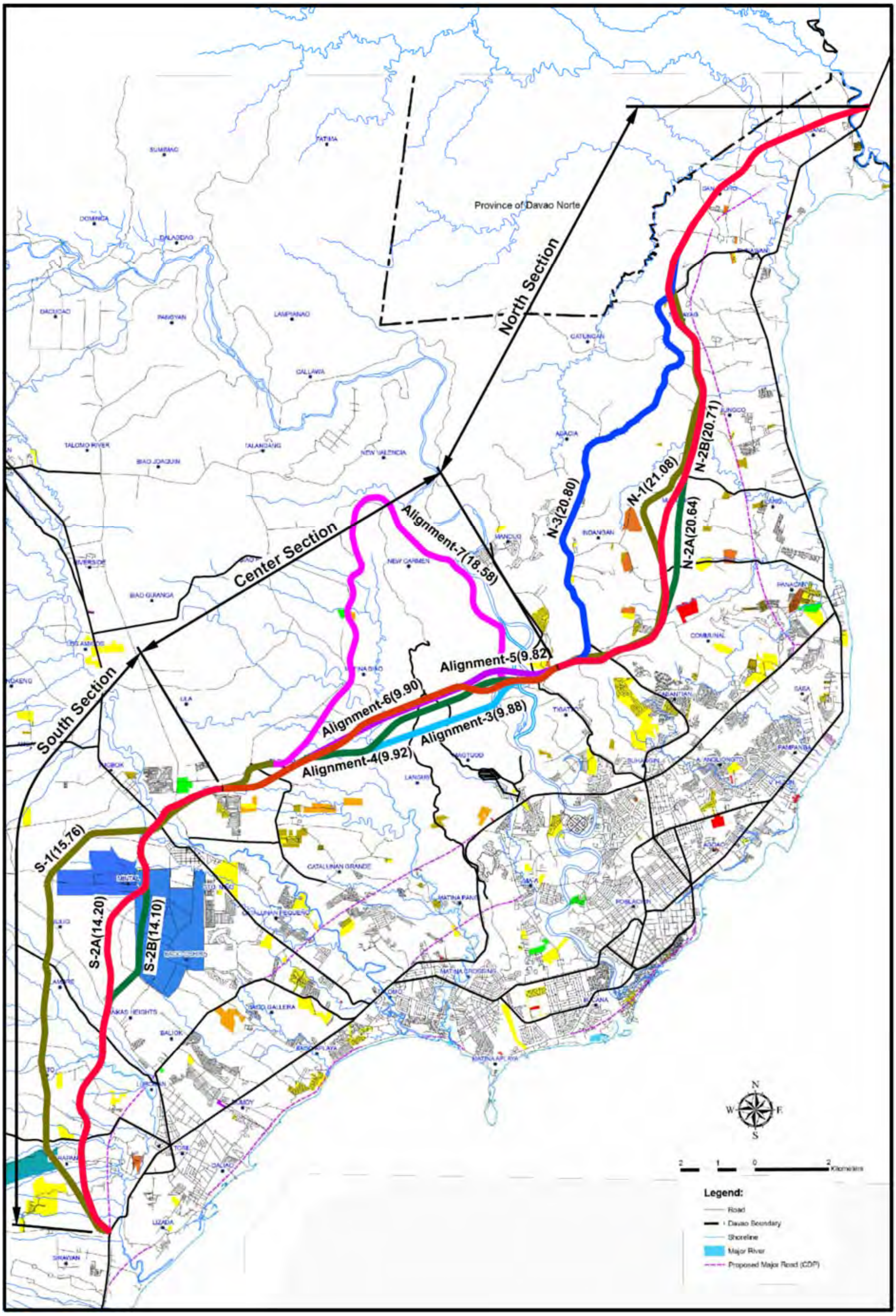


FIGURE 9.6-6 ALTERNATIVES FOR CENTER, SOUTH AND NORTH SECTIONS

(2) Evaluation Criteria

1) <u>For items quantified,</u> the following criteria were established:

• For the alternative which achieve the lowest value (or highest value)	⇨	Good (○)
• For the alternative within 10% difference compared to the lowest (or highest)	⇨	Medium (△)
• For the alternative over 20% difference compared to the lowest (or highest)	⇨	Bad (X)

2) <u>For items narratively described,</u> impact was subjectively evaluated.

3) <u>When all alternatives have the same value,</u> the item(s) was not evaluated.

4) <u>Evaluation</u>

- Assessed by <u>number</u> of items evaluated as "Good", "Medium", and "Bad".
- An alternative which has more number of "Good" and least number of "Bad".

5) <u>Overall Evaluation</u>

Two (2) cases were tested as follows;

<u>Case-1:</u> <u>Equal Rating</u> for all evaluation items (or no weight was considered for each item)

<u>Case-2:</u> <u>Weighted Rating</u>: Evaluation items of cost and number of houses/buildings affected were given 3 times heavier weight.

(3) Evaluation of Alternatives

Case-1 evaluation result is shown in **Table 9.6-3** and Case-2 in **Table 9.6-4**.

9.6.6 Recommendations

Alternative-6 was recommended due to the following:

<u>Traffic Volume Attracted</u>: Alternatives 3-6 would attract much more traffic than Alternative-7.

<u>Cost</u>: The cost is slightly higher than Alternative-7, but by only 2% difference.

<u>Impact to Natural Environment</u>: Almost the same evaluation result among Alternatives 3-6, but much better than Alternative-7.

<u>Number of Affected House/Buildings</u>: The least number of houses/buildings affected among all the alternatives.

Though Alternative-7 is the cheapest for O & M cost among the alternatives, attracted traffic of Alternative-7 is much lower than others. Alternative-7 will not function as a bypass road and will not contribute to the reduction of traffic problems in the Urban Center and economic activities in Mindanao as a whole. So, Alternative-6 was recommended based on the total evaluation result.

TABLE 9.6-3 EVALUATION OF ALTERNATIVES OF CENTER: CASE-1

Evaluation Item		Alt. 3		Alt. 4		Alt. 5		Alt. 6		Alt. 7	
Concept of Alternative		• To avoid a tunnel to pass under a deep valley. • To select narrower river crossing at west portal.		• To avoid passing through residential area at east side. • To select narrower river crossing at west portal.		• To achieve shorter tunnel length. • To avoid passing through residential area at east side. • To achieve more than 20m earth cover at a deep valley.		• To achieve shorter tunnel length. • To avoid passing through residential area at east side. • To achieve more than 20m earth cover at a deep valley. • To select narrower river crossing at west portal.		• Alignment which does not require a tunnel	
Road Length (km)		9.87 (+0.05km) (1.01)		9.92 (+0.1km) (1.01)		9.82 (0.0) (1.00)		9.90 (+0.08km) (1.01)		18.60 (+8.78) (1.89)	
Tunnel Length (km)		2.70 (+0.5km) (1.23)		2.90 (+0.7km) (1.32)		2.25 (+0.05km) (1.02)		2.20 (0.0) (1.00)		0	
a) Traffic Volume Attracted (veh/day in 2013 OD)	North Section: N-1 & N-2 South Section: S-2	5,320 (1.00)	○	5,320 (1.00)	○	5,320 (1.00)	○	5,320 (1.00)	○	1,619 (0.30)	X
	North Section: N-3 South Section: S-1	3,490 (1.00)	-	3,490 (1.00)	-	3,490 (1.00)	-	3,490 (1.00)	-	1.060 (0.30)	-
b)Cost (Million Php)	Construction Cost										-
	ROW Acquisition Cost										-
	Total		△		X		○		○		○
c)Connection with the Urbanized Area		• Same condition with the other alternatives	-	• Same condition with the other alts.	-	• Same condition with the other alts.	-	• Same condition with the other alts.	-	• Same condition with the other alt.	-
d)Impact on Natural Environment	Slope Cutting (m^3)	0.35 Million (1.06)	○	0.33 Million (1.00)	○	0.38 Million (1.15)	X	0.35 Million (1.06)	○	2.16 Million (6.55)	X
	Tree Cutting (km)	5.17 km (1.01)	○	5.10 km (1.00)	○	6.02 km (1.18)	X	5.20 km (1.02)	○	14.40 km (2.82)	X
	Flood(No. of crossing river)	5	-	5	-	5	-	5	-	5	-
	Earthquake(High embankment (km))	2.2 (1.00)	○	2.2 (1.00)	○	2.2 (1.00)	○	2.2 (1.00)	○	4.2 (1.91)	X
	Biology(Philippine Eagle's Habitants)	• Same condition with the other alts.	-	• Same condition with the other alts.	-	• Same condition with the other alts.	-	• Same condition with the other alts.	-	• Same condition with the other alts.	-
e)Social Impact	No. of Affected Houses/ Buildings	45 (3.75)	X	16 (1.33)	X	16 (1.33)	X	12 (1.00)	○	55 (4.58)	X
	Affected Agri-land	4.43km (1.05)	○	4.23km (1.00)	○	4.30km (1.02)	○	4.30km (1.02)	○	14.40km (3.40)	X
f)Construction Period		• Longest construction period(Special construction method required at the middle of the tunnel)	X	• Longest construction period(Special construction method required at the middle of the tunnel)	X	• Shorter construction period than Alt.3 & 4 but longer than alt. 6	△	• At approach section to east portal, bridge construction not needed, thus tunnel construction period is the shortest and easier than other tunnel alternatives	△	• No need tunnel construction, it is easiest among other alternatives	○

Evaluation Item	Alt. 3		Alt. 4		Alt. 5		Alt. 6		Alt. 7	
g) Road Network	• Almost same as other alternatives, excluding alt-7	○	• Almost same as other alternatives, excluding alt-7	○	• Almost same as other alternatives, excluding alt-7	○	• Almost same as other alternatives, excluding alt-7	○	• Not so much impact as road network formation.	X
h) Impact of Residential Development	• No so much impact of Residential Dev.	-	• No so much impact of Residential Dev.	-	• No so much impact of Residential Dev.	-	• No so much impact of Residential Dev.	-	• No so much impact of Residential Dev.	-
i) O&M Cost(Thousand Php/year)	12,416 (13.11)	X	13,299 (14.04)	X	10,428 (11.01)	X	10,204 (10.78)	X	947 (1.00)	○
Evaluation	○ = 6 △ = 1 X = 3		○ = 6 △ = 0 X = 4		○ = 5 △ = 1 X = 4		○ = 8 △ = 1 X = 1		○ = 3 △ = 0 X = 7	
Recommendation							**Recommended**			

Source: JICA Study Team

TABLE 9.6-4 EVALUATION OF ALTERNATIVES OF CENTER: CASE-2

Evaluation Item		Alt. 3		Alt. 4		Alt. 5		Alt. 6		Alt. 7	
Concept of Alternative		• To avoid a tunnel to pass under a deep valley. • To select narrower river crossing at west portal.		• To avoid passing through residential area at east side. • To select narrower river crossing at west portal.		• To achieve shorter tunnel length. • To avoid passing through residential area at east side. • To achieve more than 20m earth cover at a deep valley.		• To achieve shorter tunnel length. • To avoid passing through residential area at east side. • To achieve more than 20m earth cover at a deep valley. • To select narrower river crossing at west portal.		• Alignment which does not require a tunnel	
Road Length (km)		9.87 (+0.05km) (1.01)		9.92 (+0.1km) (1.01)		9.82 (0.0) (1.00)		9.90 (+0.08km) (1.01)		18.60 (+8.78) (1.89)	
Tunnel Length (km)		2.70 (+0.5km) (1.23)		2.90 (+0.7km) (1.32)		2.25 (+0.05km) (1.02)		2.20 (0.0) (1.00)		0	
a) Traffic Volume Attracted (veh/day in 2013 OD)	North Section: N-1 & N-2 South Section: S-2	5,320 (1.00)	○	5,320 (1.00)	○	5,320 (1.00)	○	5,320 (1.00)	○	1,619 (0.30)	X
	North Section: N-3 South Section: S-1	3,490 (1.00)	-	3,490 (1.00)	-	3,490 (1.00)	-	3,490 (1.00)	-	1.060 (0.30)	-
b)Cost (Million Php)	Construction Cost										-
	ROW Acquisition Cost										-
	Total		△		X X X		○		○		○
c)Connection with the Urbanized Area		• Same condition with the other alternatives	-	• Same condition with the other alts.	-	• Same condition with the other alts.	-	• Same condition with the other alts.	-	• Same condition with the other alt.	-
d)Impact on Natural Environment	Slope Cutting (m^3)	0.35 Million (1.06)	○	0.33 Million (1.00)	○	0.38 Million (1.15)	X	0.35 Million (1.06)	○	2.16 Million (6.55)	X
	Tree Cutting (km)	5.17 km (1.01)	○	5.10 km (1.00)	○	6.02 km (1.18)	X	5.20 km (1.02)	○	14.40 km (2.82)	X
	Flood(No. of crossing river)	5	-	5	-	5	-	5	-	5	-
	Earthquake (High embankment (km))	2.2 (1.00)	○	2.2 (1.00)	○	2.2 (1.00)	○	2.2 (1.00)	○	4.2 (1.91)	X

Evaluation Item		Alt. 3		Alt. 4		Alt. 5		Alt. 6		Alt. 7	
	Biology(Philippine Eagle's Habitants)	• Same condition with the other alts.	-	• Same condition with the other alts.	-	• Same condition with the other alts.	-	• Same condition with the other alts.	-	• Same condition with the other alts.	-
e)Social Impact	No. of Affected Houses/ Buildings	45 (3.75)	X X X	16 (1.33)	X X X	16 (1.33)	X X X	12 (1.00)	○	55 (4.58)	X X X
	Affected Agri-land	4.43km (1.05)	○	4.23km (1.00)	○	4.30km (1.02)	○	4.30km (1.02)	○	14.40km (3.40)	X
f)Construction Period		• Longest construction period(Special construction method required at the middle of the tunnel)	X	• Longest construction period(Special construction method required at the middle of the tunnel)	X	• Shorter construction period than Alt.3 & 4 but longer than alt. 6	△	• At approach section to east portal, bridge construction not needed, thus tunnel construction period is the shortest and easier than other tunnel alternatives	△	• No need tunnel construction, it is easiest among other alternatives	○
g) Road Network		• Almost same as other alternatives, excluding alt-7	○	• Almost same as other alternatives, excluding alt-7	○	• Almost same as other alternatives, excluding alt-7	○	• Almost same as other alternatives, excluding alt-7	○	• Not so much impact as road network formation.	X
h) Impact of Residential Development		• No so much impact of Residential Dev.	-	• No so much impact of Residential Dev.	-	• No so much impact of Residential Dev.	-	• No so much impact of Residential Dev.	-	• No so much impact of Residential Dev.	-
i) O&M Cost(Thousand Php/year)		12,416 (13.11)	X	13,299 (14.04)	X	10,428 (11.01)	X	10,204 (10.78)	X	947 (1.00)	○
Evaluation		○ = 6 △ = 1 X = 5		○ = 6 △ = 0 X = 8		○ = 5 △ = 1 X = 6		○ = 8 △ = 1 X = 1		○ = 3 △ = 1 X = 9	
Recommendation								**Recommended**			

Source: JICA Study Team

9.7 SELECTION OF SOUTH SECTION ALIGNMENT

9.7.1 General Characteristics of the South Area

Characteristics of the south area are as follows;

- Located at the foot of Mt. Apo.
- Due to rivers and valleys, the topography is undulating.
- Urbanization is progressing towards the mountain side from Davao – General Santos Road and Davao – Bukidnon Road.
- The University of the Philippines-Mindanao (UP-Mindanao) owns wide area of land in the Bypass Corridor.
- The Bureau of Plant and Industry (BPI) and the Philippine Coconut Authority (PCA) owns wide area of land in the Bypass Corridor.
- The horse racing track was recently developed near the beginning of the Bypass.
- Possible space (corridor) for the Bypass is shown in **Figure 9.5-2**.

9.7.2 Alternative Alignments of the South Section

Three (3) alternative alignments were studied as shown in **Figure 9.7-1**.

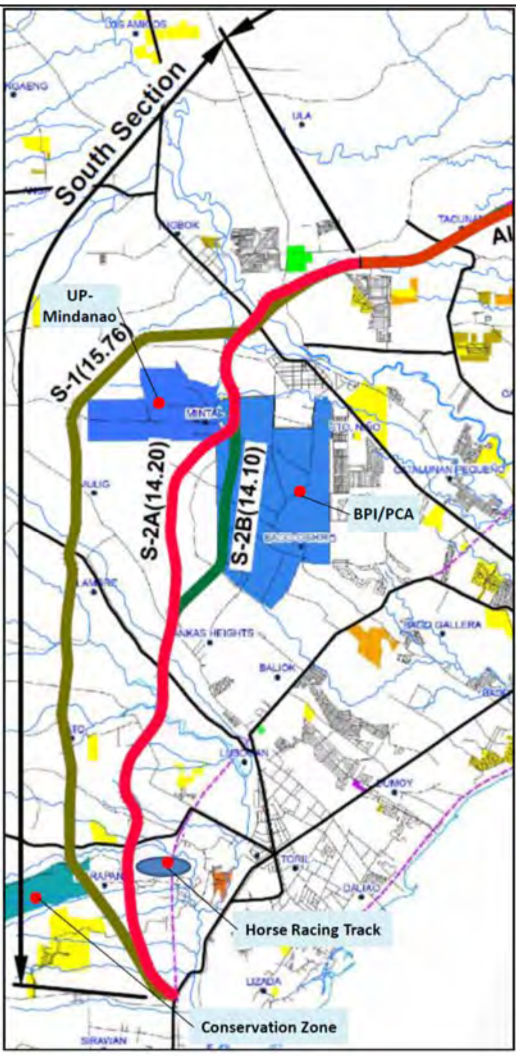


FIGURE 9.7-1 ALTERNATIVE ALIGNMENTS SOUTH SECTION

<u>Alignment S-1</u>

- This is the alignment proposed by the business Case Study.
- The alignment is generally far from the existing urbanized area.
- It avoids passing through UP-Mindanao land and passes west side of UP-Mindanao.
- Topography is undulating, thus high cut of slope, high embankment and longer bridges are required.

<u>Alignment S-2A</u>

- The alignment selected is closer to the existing urbanized area.
- It passes between UP-Mindanao and BPI.
- It avoids the Conservation Area.
- It passes near the recently developed Horse Racing Track.
- The topography is gentler than S-1, but many river has to be crossed.
- Most of the lands along the alignment are designated as "Residential Area" in the Davao City Future Land Use Plan.

<u>Alignment S-2B</u>

- The only difference between S-2A and S-2B is whether the alignment passes through BPI/PCA land. This alternative alignment passes through BPI/PCA land.
- There are many informal settlers in the BPI/PCA land which is a Government Land.

Source: JICA Study Team

9.7.3 Evaluation of Alternatives

The same evaluation criteria adopted for the Center Section were used. Evaluation results are shown in **Table 9.7-1** for Case-1 and **Table 9.7-2** for Case-2.

TABLE 9.7-1 EVALUATION OF ALTERNATIVES OF SOUTH SECTION: CASE-1

Evaluation Item			S-1		S-2A		S-2B	
Concept of Alternative			• Alignment selected by BCS • Not to affect UP Mindanao land		• Closer to existing urbanized area • Pass through future residential area		• Closer to existing urbanized area • Pass through BPI/PCA land	
Road Length (km)			15.8 (+1.7km) (1.12)		14.2 (+0.1km) (1.01)		14.1 (0.00) (1.00)	
a) Traffic Volume Attracted (veh/day in 2013 OD)	North Section	N-1, N-2	2,680 (0.54)	X	4,990 (1.00)	○	4,990 (1.00)	○
		N-3	2,360 (0.52)		4,540 (1.00)		4,540 (1.00)	
b) Cost (Million Php)	Construction Cost							
	ROW Acquisition Cost							
	Total			X		○		○
O&M Cost (Thousand Php/Year)			947 (1.21)	X	789 (1.00)	○	784 (1.00)	○
c) Connection with the Urbanized Area			• Far from the urbanized area	△	• Nearer to the urbanized area	○	• Nearer to the urbanized area	○
d) Impact on Natural Environment	Slope Cutting (m^3)		1.76 Million (3.59)	X	0.49 Million (1.00)	○	0.50 Million (1.02)	○
	Tree Cutting (km)		13.5 (1.08)	○	12.5 (1.00)	○	12.5 (1.00)	○
	Flood (No. of crossing river)		10	-	10	-	10	-
	Earthquake(High Embankment(km))		2.5 (2.77)	X	0.9 (1.00)	○	0.9 (1.00)	○
	Biology(Location of Philippine Eagle's Habitants)		• Nearer than other alternatives, but still far distance (more than 10km)	△	• Far from Mt. Apo, Philippine Eagle's habitants	○	• Far from Mt. Apo, Philippine Eagle's habitants	○
e) Social Impact	No. of Affected Houses/Buildings		85 (1.55)	X	55 (1.00)	○	64 (1.16)	X
	Affected Agri-land (km)		14.2 (1.03)	○	13.8 (1.00)	○	13.8 (1.00)	○
f) Construction Period			• Same condition with the other alternatives	-	• Same condition with the other alternatives	-	• Same condition with the other alternatives	-
g) Road Network			• Same condition with the other alternatives	-	• Same condition with the other alternatives	-	• Same condition with the other alternatives	-
h) Impact of Residential Development			• Passes through Conservation Area for 400m	X	• Passes through future Residential Area, thus vitally support residential area development	○	• Does not fully support future residential area development	X
i) O&M Cost (Thousand Php/Year)			947 (1.21)	X	789 (1.00)	○	784 (1.00)	○
j) Other Aspects	Positive							
	Negative		• This scheme adversely affect traffic attraction at both centre and north sections	X				
Evaluation			○ = 2 △ = 2 X = 9		○ = 12 △ = 0 X = 0		○ = 10 △ = 0 X = 2	
Recommendation					**Recommended**			

Source: JICA Study Team

TABLE 9.7-2 EVALUATION OF ALTERNATIVES OF SOUTH SECTION: CASE-2

Evaluation Item			S-1		S-2A		S-2B	
Concept of Alternative			• Alignment selected by BCS • Not to affect UP Mindanao land		• Closer to existing urbanized area • Pass through future residential area		• Closer to existing urbanized area • Pass through BPI/PCA land	
Road Length (km)			15.8 (+1.7km) (1.12)		14.2 (+0.1km) (1.01)		14.1 (0.00) (1.00)	
a) Traffic Volume Attracted (veh/day in 2013 OD)	North Section	N-1, N-2	2,680 (0.54)	X	4,990 (1.00)	○	4,990 (1.00)	○
		N-3	2,360 (0.52)		4,540 (1.00)		4,540 (1.00)	
b) Cost (Million Php)	Construction Cost							
	ROW Acquisition Cost							
	Total			XXX		○		○
O&M Cost (Thousand Php/Year)			947 (1.21)	X	789 (1.00)	○	784 (1.00)	○
c) Connection with the Urbanized Area			• Far from the urbanized area	△	• Nearer to the urbanized area	○	• Nearer to the urbanized area	○
d) Impact on Natural Environment	Slope Cutting (m^3)		1.76 Million (3.59)	X	0.49 Million (1.00)	○	0.50 Million (1.02)	○
	Tree Cutting (km)		13.5 (1.08)	○	12.5 (1.00)	○	12.5 (1.00)	○
	Flood (No. of crossing river)		10	-	10	-	10	-
	Earthquake(High Embankment(km))		2.5 (2.77)	X	0.9 (1.00)	○	0.9 (1.00)	○
	Biology(Location of Philippine Eagle's Habitants)		• Nearer than other alternatives, but still far distance (more than 10km)	△	• Far from Mt. Apo, Philippine Eagle's habitants	○	• Far from Mt. Apo, Philippine Eagle's habitants	○
e) Social Impact	No. of Affected Houses/Buildings		85 (1.55)	XXX	55 (1.00)	○	64 (1.16)	XXX
	Affected Agri-land (km)		14.2 (1.03)	○	13.8 (1.00)	○	13.8 (1.00)	○
f) Construction Period			• Same condition with the other alternatives	-	• Same condition with the other alternatives	-	• Same condition with the other alternatives	-
g) Road Network			• Same condition with the other alternatives	-	• Same condition with the other alternatives	-	• Same condition with the other alternatives	-
h) Impact of Residential Development			• Passes through Conservation Area for 400m	X	• Passes through future Residential Area, thus vitally support residential area development	○	• Does not fully support future residential area development	X
i) O&M Cost (Thousand Php/Year)			947 (1.21)	X	789 (1.00)	○	784 (1.00)	○
j) Other Aspects	Positive							
	Negative		• This scheme adversely affect traffic attraction at both centre and north sections	X				
Evaluation			○ = 2 △ = 1 X = 13		○ = 12 △ = 0 X = 0		○ = 10 △ = 0 X = 4	
Recommendation					**Recommended**			

Source: JICA Study Team

9.7.4 Recommendations

Alternative S-2A is recommended due to the following:

- **Traffic Volume Attracted:** more traffic will be attracted than Alternative S-1. The same traffic as Alternative S-2B will be attracted.

- **Cost:** the cost is slightly higher than Alternative S-2B, but only 2% difference.

- **Impact on Natural Environment:** Almost the same evaluation as Alternative S-2B. Much better than Alternative S-1.

- **Number of Affected Houses/Buildings:** The least number of houses/buildings affected among the three alternatives.

- **Compatibility with the Future Land Use:** Alignment S-2B passes the government land (UP-Mindanao and BPI/PCA) and Alignment S-2A passes the private land. Alternative S-2A vitally supports the future residential area development, whereas Alternative S-2B passes through BPI/PCA land where the urbanization is restricted. To avoid passing the alignment in the BPI/PCA area is also better than that in the private land due to minimization of the tree-cutting.

9.8 SELECTION OF NORTH SECTION ALIGNMENT

9.8.1 Where to End the Bypass

The Bypass is connected to Daang Maharlika at the north end. There are two (2) options for the end point as shown in **Figure 9.8-1**.

Option-1: End the Bypass between Bunawan and Licanan within Davao City.

Option-2: End the Bypass at the boundary between Davao City and Panabo City.

Option-1 is the end point recommended by BCS, however, DPWH Region XI recommended to extends the Bypass and end at the beginning of Panabo City. The reasons are as follows;

- ROW width of Daang Maharlika is
    - Within Davao City ……….. 30m
    - In Panabo City …………… 60m

- Lasang Bridge at the boundary between Davao City and Panabo City was built with a 4-lane bridge. Both sides of this bridge have been fully developed, thus further widening of the bridge is difficult.

- Lasang area of Daang Maharlika will be a traffic bottleneck in the future.

- Whereas, Daang Maharlika within Panabo City has wide road ROW of 60m. various measures can be adopted, when traffic congestion becomes a proble.

- Panabo City is also fast growing city and urbanization along Daang Maharlika is progressing, thus roadsides will be fully urbanized. Extension of the Bypass to Panabo City will become quite difficult, unless the Bypass is extended now.

- When the Bypass is extended to Panabo City, access to Panabo Port will be improved.

In view of the above, **it is recommended that the Bypass should be extended up to the beginning of Panabo City and connected with Daang Maharlika which has 60m road ROW.**

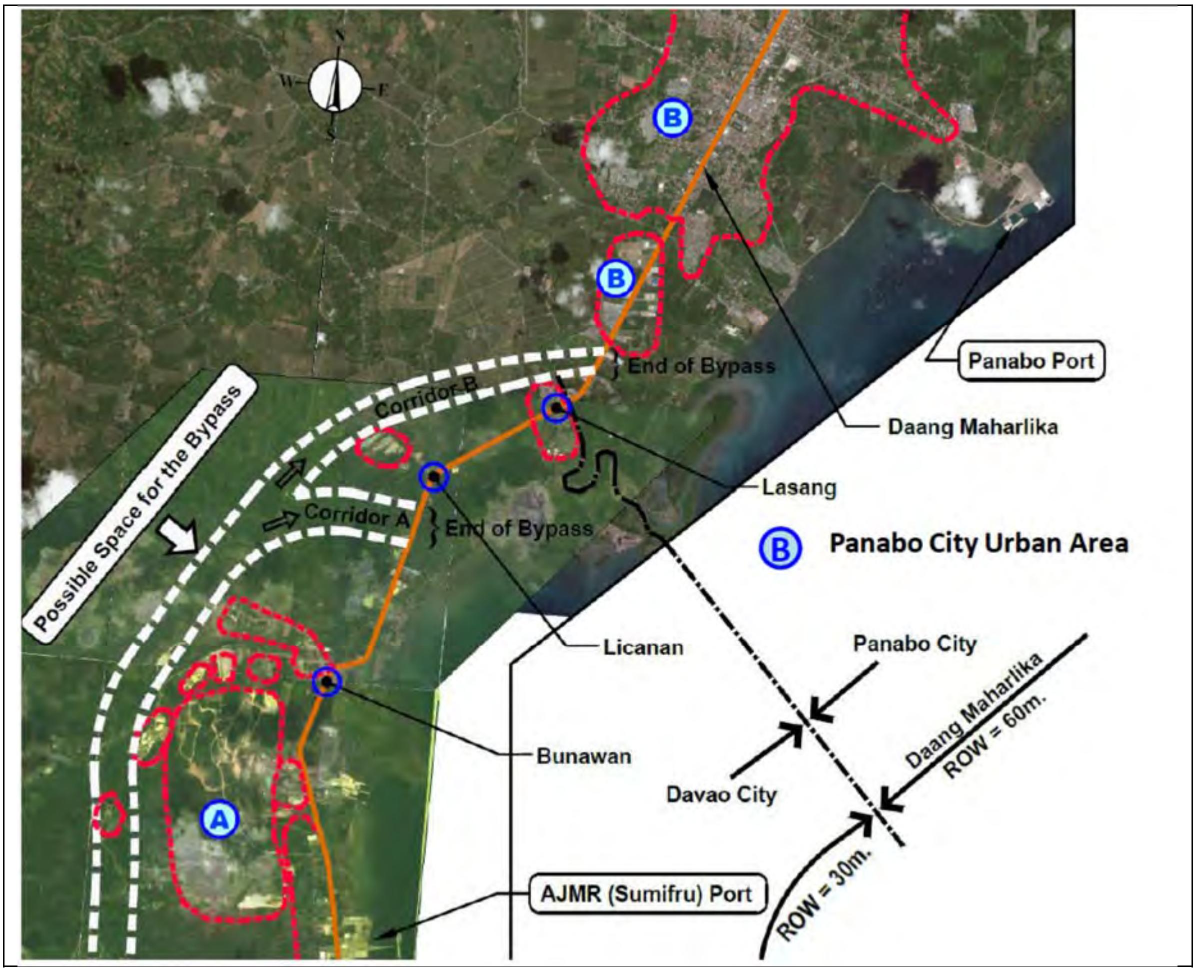


FIGURE 9.8-1 CONDITION OF BYPASS AT THE NORTH END AREA

Cost Comparison

Alignments of Option-1 and Option-2 are shown in **Figure 9.8-2**, and estimated construction cost and ROW cost are shown in **Table 9.8-1**.

TABLE 9.8-1 COST OF OPTION-1 AND OPTION-2

		Option-1	Option-2	
			Option-2 Cost	Additional Cost
Road Length (km)		**2.5**	**5.3**	**+2.8**
Bridge Length (m)		70.0	130.0	+60.0
Cost (Million Php)	Construction Cost			
	ROW Cost			
	Total			

Source: JICA Study Team

FIGURE 9.8-2 ALIGNMENTS OF OPTION-1 AND OPTION-2

9.8.2 Alternatives of North Section

Four (4) alternatives were developed and compared as shown in **Figure 9.8-3**.

<u>**Alignment N-1**</u>

- The alignment proposed by BCS.
- This alignment goes towards inland area at the mid-setion, resulting in far from the urbanized area and longer road length.

<u>**Alignment N-2A**</u>

- Closer to the urbanized area and shorter road length than Alternative N-1.

<u>**Alignment N-2B**</u>

- Same concept as Alternative N-2A.

<u>**Alignment N-3**</u>

- To convert the existing City Road to the Bypass.

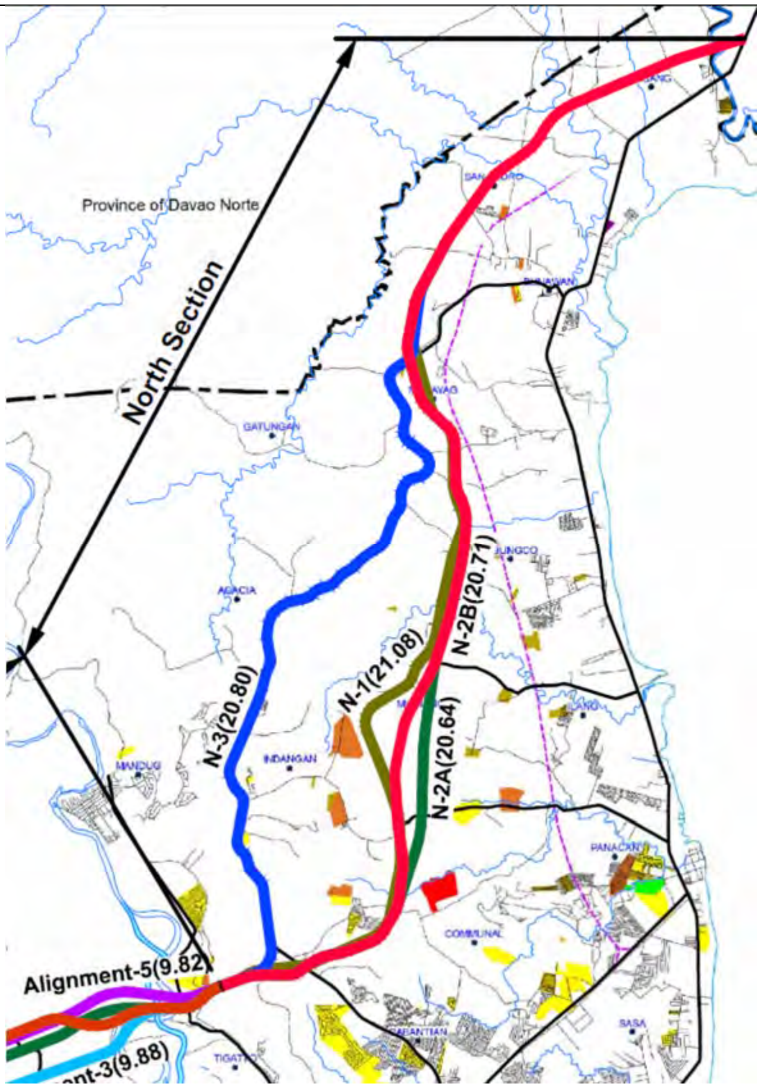


FIGURE 9.8-3 ALTERNATIVE ALIGNMENTS IN NORTH SECTION

9.8.3 Evaluation of Alternatives

(1) Evaluation Criteria

The same evaluation criteria adopted for the Center Section.

(2) Evaluation Result

Evaluation results are shown in **Table 9.8-2** for Case-1 and **Table 9.8-3** for Case-2.

TABLE 9.8-2 EVALUATION OF ALTERNATIVES OF NORTH SECTION: CASE-1

Evaluation Item			N-1		N-2A		N-2B		N-3	
Concept of Alternative			• Alignment selected by BCS		• Closer to urbanized area than N-1		• Closer to urbanized area than N-1		• To convert existing city road to bypass	
Road Length (km)			21.1 (+0.5km) (1.02)		20.6 (0.0) (1.00)		20.7 (+0.1km) (1.00)		20.8 (+0.2km) (1.01)	
a) Traffic Volume Attracted (veh/day in 2013)	South Section	S-2A, S-2B	4,270 (1.00)	○	4,270 (1.00)	○	4,270 (1.00)	○	3,850 (0.90)	△
		S-1	3,150 (1.00)		3,150 (1.00)		3,150 (1.00)		2,690 (0.85)	
b) Project Cost (Million Php)	Construction Cost									-
	ROW Acquisition Cost									-
	Total			X		X		X		○
c) Connection with the Urbanized Area			• Nearer than N-3	○	• Nearer than N-3	○	• Nearer than N-3	○	• Far from Urbanized Area	△
d) Impact on Natural Environment	Slope Cutting (m^3)		2.45 Million (3.45)	X	1.10 Million (1.55)	X	0.96 Million (1.35)	X	0.71 Million (1.00)	○
	Tree Cutting (km)		17.0 (1.06)	○	17.0 (1.06)	○	16.8 (1.04)	○	16.1 (1.00)	○
	Flood(No. of crossing river)		5	-	5	-	5	-	5	-
	Earthquake(High embankment (km))		5.0 (10.0)	X	2.3 (4.60)	X	1.9 (3.80)	X	0.5 (1.00)	○
	Biology(Philippine Eagle's Habitants)		• Same condition with the other alternatives	-	• Same condition with the other alternatives)	-	• Same condition with the other alternatives (far from Mt. Apo, Philippine Eagle's habitants)	-	• Same condition with the other alternatives (far from Mt. Apo, Philippine Eagle's habitants)	-
e) Social Impact	No. of Affected Houses/ Buildings		270 (4.66)	X	60 (1.03)	○	58 (1.00)	○	780 (13.40)	X
	Affected Agri-land (km)		15.7 (1.03)	○	15.8 (1.03)	○	15.3 (1.00)	○	16.3 (1.07)	○
f) Construction Period			• Shorter construction period than N-3	○	• Shorter construction period than N-3	○	• Shorter construction period than N-3	○	• Longer construction period due to utilizing existing road. • Existing traffic on the city road is adversely affected during construction	X
g) Road Network			• Road network in north area is strengthened due to additional new link	○	• Road network in north area is strengthened due to additional new link	○	• Road network in north area is strengthened due to additional new link	○	• Less contribution for strengthening of road network	X
h) Impact of Residential Development			• Same condition with the other alternatives	-	• Same condition with the other alternatives	-	• Same condition with the other alternatives	-	• Same condition with the other alternatives	-
i) O&M Cost(Thousand Php/year)			1,184 (1.10)	X	1,225 (1.13)	X	1,210 (1.12)	X	1,080 (1.00)	○
j) Other Aspects	Positive		• Attract more traffic in the south and centre sections	○	• Attract more traffic in the south and centre sections	○	• Attract more traffic in the south and centre sections	○	• This scheme adversely affect traffic attraction at both south and centre sections.	X
	Negative								• Implementation is difficult due to	

Evaluation Item		N-1		N-2A		N-2B		N-3	
								large number of house relocation	X
Evaluation		○ = 7 △ = 0 X =5		○ = 8 △ = 0 X = 4		○ = 8 △ = 0 X =4		○ = 6 △ = 2 X = 5	
Recommendation						**Recommended**			

Source: JICA Study Team

TABLE 9.8-3 EVALUATION OF ALTERNATIVES OF NORTH SECTION: CASE-2

Evaluation Item			N-1		N-2A		N-2B		N-3	
Concept of Alternative			• Alignment selected by BCS		• Closer to urbanized area than N-1		• Closer to urbanized area than N-1		• To convert existing city road to bypass	
Road Length (km)			21.1 (+0.5km) (1.02)		20.6 (0.0) (1.00)		20.7 (+0.1km) (1.00)		20.8 (+0.2km) (1.01)	
a) Traffic Volume Attracted (veh/day in 2013)	South Section	S-2A, S-2B	4,270 (1.00)	○	4,270 (1.00)	○	4,270 (1.00)	○	3,850 (0.90)	△
		S-1	3,150 (1.00)		3,150 (1.00)		3,150 (1.00)		2,690 (0.85)	
b) Project Cost (Million Php)	Construction Cost									
	ROW Acquisition Cost									
	Total			XXX		XXX		XXX		○
c) Connection with the Urbanized Area			• Nearer than N-3	○	• Nearer than N-3	○	• Nearer than N-3	○	• Far from Urbanized Area	△
d) Impact on Natural Environment	Slope Cutting (m^3)		2.45 Million (3.45)	X	1.10 Million (1.55)	X	0.96 Million (1.35)	X	0.71 Million (1.00)	○
	Tree Cutting (km)		17.0 (1.06)	○	17.0 (1.06)	○	16.8 (1.04)	○	16.1 (1.00)	○
	Flood(No. of crossing river)		5	-	5	-	5	-	5	-
	Earthquake(High embankment (km))		5.0 (10.0)	X	2.3 (4.60)	X	1.9 (3.80)	X	0.5 (1.00)	○
	Biology(Philippine Eagle's Habitants)		• Same condition with the other alternatives	-	• Same condition with the other alternatives)	-	• Same condition with the other alternatives (far from Mt. Apo, Philippine Eagle's habitants)	-	• Same condition with the other alternatives (far from Mt. Apo, Philippine Eagle's habitants)	-
e) Social Impact	No. of Affected Houses/ Buildings		270 (4.66)	XXX	60 (1.03)	○	58 (1.00)	○	780 (13.40)	XXX
	Affected Agri-land (km)		15.7 (1.03)	○	15.8 (1.03)	○	15.3 (1.00)	○	16.3 (1.07)	○
f) Construction Period			• Shorter construction period than N-3	○	• Shorter construction period than N-3	○	• Shorter construction period than N-3	○	• Longer construction period due to utilizing existing road. • Existing traffic on the city road is adversely affected during construction	X
g) Road Network			• Road network in north area is strengthened due to additional new link	○	• Road network in north area is strengthened due to additional new link	○	• Road network in north area is strengthened due to additional new link	○	• Less contribution for strengthening of road network	X

Evaluation Item		N-1		N-2A		N-2B		N-3	
h) Impact of Residential Development		• Same condition with the other alternatives	-	• Same condition with the other alternatives	-	• Same condition with the other alternatives	-	• Same condition with the other alternatives	-
i) O&M Cost(Thousand Php/year)		1,184 (1.10)	X	1,225 (1.13)	X	1,210 (1.12)	X	1,080 (1.00)	○
j) Other Aspects	Positive	• Attract more traffic in the south and centre sections	○	• Attract more traffic in the south and centre sections	○	• Attract more traffic in the south and centre sections	○	• This scheme adversely affect traffic attraction at both south and centre sections.	X
	Negative							• Implementation is difficult due to large number of house relocation	X
Evaluation		○ = 7 △ = 0 X = 9		○ = 8 △ = 0 X = 6		○ = 8 △ = 0 X = 6		○ = 6 △ = 2 X = 7	
Recommendation						**Recommended**			

Source: JICA Study Team

9.8.4 Recommendations

It is recommended that **Alternative N-2B should be adopted for the North Section.** Although Alternative N-3 is the cheapest alternative, it has the following disadvantages.

- It is intended to convert the existing City Road where its roadsides are rapidly urbanizing. It is estimated that 780 houses/buildings (or about 3,350 people) are required to be relocated, which will cause various social problems.
- Implementation of relocation of this magnitude will take a long time, thus completion of the Bypass will be much delayed than other alternatives.
- Since this alignment is far from the existing urban areas, less traffic will be attracted.
- This alignment also affects traffic attraction of South and Center Sections, thus overall viability will be affected.
- This alternative contributes less for strengthening of road network in the north area.
- During construction, existing traffic on this City Road is adversely affected due to construction work.

Alternative N-1 is disadvantageous for the following items compared to Alternative N-2.

- Construction cost is much higher.
- Environmentally less advantageous due to more slope cutting required.
- Socially less advantageous due to high number of houses/buildings to be relocated.

Alternative N-2A and N-2B

Both alternatives were evaluated almost the same. The only difference is the construction cost. Alternative N-2B is recommended due to less construction cost than Alternative N-2A.

9.9 ZERO OPTION

Table 9.9-1 shows the evaluation of with project and without project.

Though Project will affect the pollution, natural environment and social environment, traffic will be drastically improved in the city area.

TABLE 9.9-1 EVALUATION OF WITH/WITHOUT PROJECT

Evaluation Item	Parameter	With Project	Without Project	Remarks
Traffic	Total Travel Time (Y2023)	216,682 veh*hrs/day ○	235,299 veh*hrs/day X	18,617 veh*hrs saving in Davao City
Pollution	Air, Noise	Air pollution and noise will occur during construction X	None ○	Along Bypass Area
	CO_2 (Y2023)	642,400 ton/year ○	676,968 ton/year X	34,568 ton/year decrease during operation
Natural Environment		Tree cutting slope cutting may occur during construction X	None ○	
Social Environment		Resettlement necessary (125 structures) X	None ○	

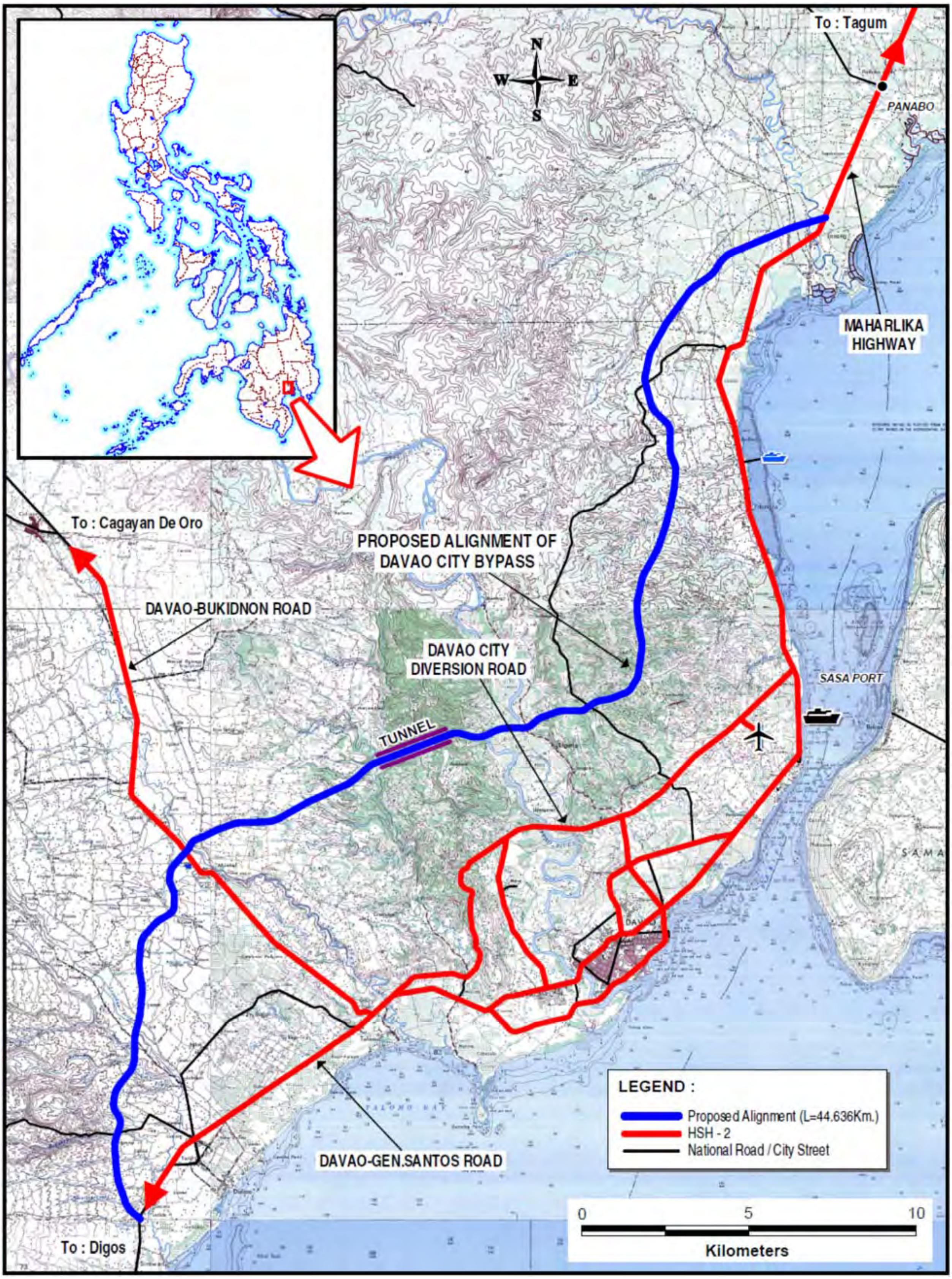
Source: JICA Study Team

9.10 RECOMMENDED ALIGNMENT OF THE BYPASS

Recommended alignment of the Bypass is shown in **Figure 9.10-1**. Outline of the selected alignment is shown in **Table 9.10-1**. **Figure 9.10-2** shows the relation between the selected bypass alignment and the future Davao City Land Use Plan.

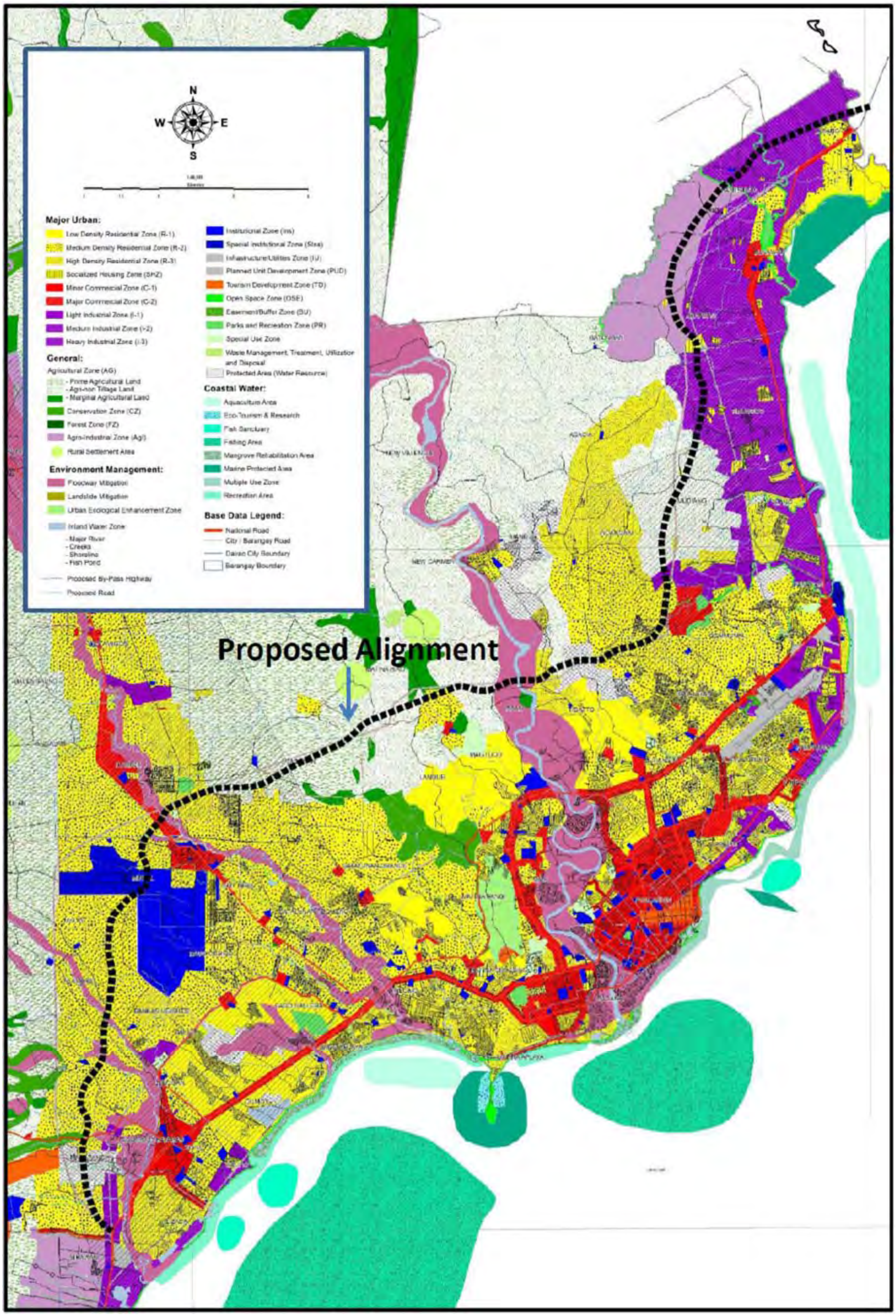
TABLE 9.10-1 OUTLINE OF THE BYPASS

(CONFIDENTIAL)



Source: JICA Study Team

FIGURE 9.10-1 RECOMMENDED ALIGNMENT OF THE BYPASS



Source: JICA Study Team

FIGURE 9.10-2 FUTURE LAND USE PLAN AND THE BYPASS ALIGNMENT

CHAPTER 10
PRELIMINARY DESIGN

10.1 ENGINEERING SURVEYS UNDERTAKEN

10.1.1 General

This section describes the engineering surveys undertaken.

(1) Topographical Survey

(2) Soils and Geo-technical Survey

10.1.2 Topographical Survey

Table 10.1-1 shows the summary of survey works conducted.

TABLE 10.1-1 SUMMARY OF TOPOGRAPHICAL SURVEYS

No.	Items	Value	Remarks
1	Coordinate Grid	PRS-92, WGS-84	
2	Methodology	Confirmed to DAO* DENR regulation	
3	Reference for Horizontal	NAMRIA DVS-3569	4th Order
4	Reference for Vertical	NAMRIA DS-19 NAMRIA DS-134	1st Order 1st Order
5	Road Centerline Survey	44.6km	50m interval
6	Road Centerline Profile Survey	44.6km	50m interval
7	Cross Sections Survey		Every 50m interval, 125m both sides from Centerline
8	Structure Survey	All Structures	Total 250m width
9	River Survey	20 rivers	Total Length 500, 5 river cross section
10	Intersection Survey	3 (4 to 6-lane road) 31 (2-lane road)	L = 600m, W = 50m L = 400m, W = 30m

***DAO – Department Administrative Order, DENR – Department of Environment and Natural Resources

10.1.3 Soils and Geo-technical Investigation

(1) General Geology

1) Topography

The general landscape of the project site is marked by complex morphologies which are controlled by the geological structures. Most of the geological structures are associated either by faults and/or stratigraphic lines. The relief varies from rolling hills to rugged mountains with elevations between 10m and 220m.

The topography manifests high dissection particularly towards the mountainous and rugged relief where passages of faults and various geologic lineaments are strongly manifested. The mountainous and high relief areas appear generally elongated towards the north - northwest. This elongation runs roughly co-linear with the direction of anticlines and synclines of Quaternary-Tertiary sedimentary rocks.

Most of the drainage-lines in and around the project site are structurally-controlled. They flow generally from west - northwest towards east - southeast. All empty their loads towards Davao Gulf in the east.

The project site of the bypass road is crisscrossed by several geologic structures and lineaments.

Most prominent are faults, geologic lineaments, synclines and anticlines. In many places in and around the project site, the prominence of geologic structures and lineaments are notably earmarked by the alignment of several structural outliers.

Faults and geologic lineaments are linear fractures or fracture zones along which there has occurred displacement of the slides relative to one another and parallel to the fracture. In and around the project site, faults/geologic lineaments are linear features and semi-straight lines marked with scarps. These scarps characterize the dip-slope displacements. In many places, these scarps appear almost vertical. Also sites exhibits extensive erosion activity along these scarps.

The proposed alignment of the bypass road is intersected with two systems of geologic lineament which are the west - northwest (W-NW) system and the north - northeast (N-NE) system.

The west - northwest (W-NW) system appears older and tentatively classified as “inactive”. This system of geologic lineament variably strikes between 45 degrees northwest and due west. The inclined directions of fracture variably dip toward of the south - southwest between 20 and 35 degrees. Scarps of this fault system are marked with severe weathering and infilling of soil materials, but brecciation is minor. The densely vegetated states of the sites suggest water seepage.

The north - northeast (N-NE) system appears younger and “Recently active” based on morphological features along Davao River. This system of geologic lineament hinders the current of Davao River contributing to the current avulsion, pulsative shifts and migrations of the river channel. This system of geologic lineament variably strike between 30 degrees northeast and due north. The inclined directions of fracture variably dip toward of the northwest - west between 20 and 35 degrees. Associated scarps of this geologic lineament expose poorly weathered bedrocks with minor clay and infilling soils, and brecciation is extensive. Sites are poorly vegetated which suggest poor availability of water seepage.

The project site is underlain by folded Tertiary-Quaternary sedimentary rocks and clastic. Presence of folded structures is discernible on several outcrops of sedimentary rocks. Most observable fold structures are anticlines and synclines in the area between Barangay Langub and Waan which will be crossed by the tunnel alignment. This structural morphology in around the tunnel alignment is characteristic feature of hogback and monoclonal ridges mostly underlain by folded Tertiary sedimentary rocks.

2) Geological Features

The stratigraphic sequence of the subsoil and rock types found along the bypass road and surrounding area is shown in **Table 10.1-2** based on the mapping of the Mines and Geosciences Bureau Region XI.

In addition the geological map of the site is shown in **Figure 10.1-1**.

TABLE 10.1-2 STRATIGRAPHIC SEQUENCE OF SUBSOIL AND ROCK TYPES FOUND ALONG BYPASS ROAD AND SURROUNDING AREA

Formation	Description	Geologic Age
Alluvium	Loose, unconsolidated gravel, sand and clay deposits	Holocene (Recent)
Tigatto Terrace Gravel	Loosely stratified gravel and sand deposits	Holocene

<table>
<tr><th colspan="2">Formation</th><th>Description</th><th>Geologic Age</th></tr>
<tr><td colspan="2">Bunawan Limestone</td><td>Coralline limestone</td><td>Late Pleistocene</td></tr>
<tr><td rowspan="3">Apo Volcanic Complex</td><td>Apo Volcanics</td><td>Intercalated pyroclastics and volcaniclastics with lenses of volcanic ash</td><td>Pleistocene</td></tr>
<tr><td>Talomo Volcanics</td><td>Volcanic flows with intercalated pyroclastics, tuff and volcaniclastics</td><td>Pleistocene</td></tr>
<tr><td>Apo-Talomo Volcanic Cones</td><td>Andesitic-dacitic volcanic lava</td><td>Pleistocene</td></tr>
<tr><td colspan="2">Mandog Formation</td><td>Interbedded consolidated sand and clay with minor gravels</td><td>Early to Late Pleistocene</td></tr>
<tr><td colspan="2">Masuhi Formation</td><td>Interbedded sandstone and shale with lenses of conglomerate</td><td>Late Miocene to Early Pliocene</td></tr>
</table>

Source: Modified from "Mines and Geo-Sciences Bureau"

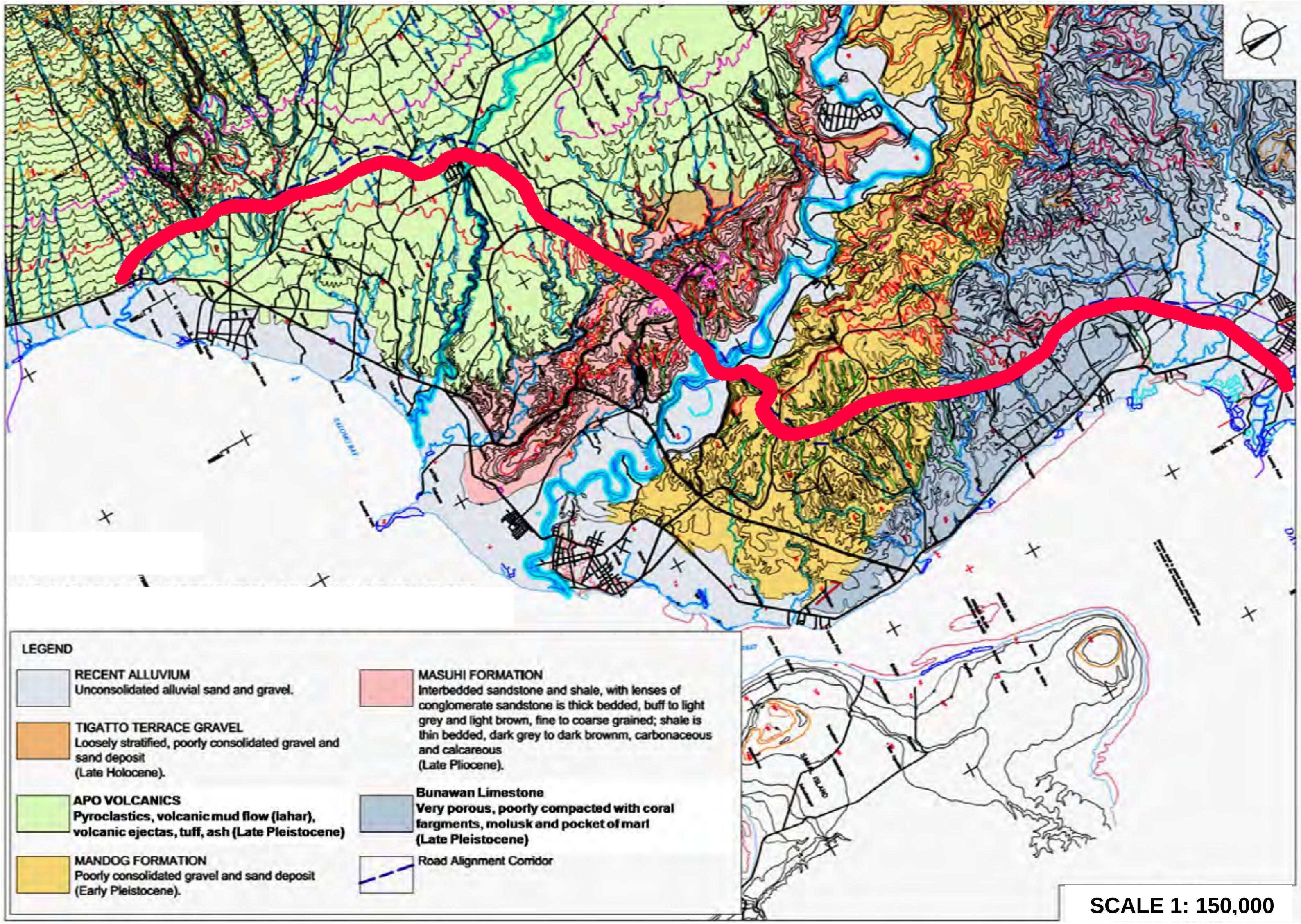


FIGURE 10.1-1 GEOLOGICAL MAP OF THE SITE

The summaries of each subsoil and rocks along the bypass road and surrounding area are as follows:

(a) Alluvium

The alluvium is deposits consisting of alternation layers of soft cohesive soil, loose sandy soil and gravels of Holocene (Recent). This alluvium is mainly laid at the area along Davao River and the end point area of the bypass road (northeastern area).

(b) Tigatto Terrace Gravel

The Tigatto Terrace Gravel is deposits consisting of poorly stratified, poorly compacted layers of gravel and sand with thickness of 0.5-2.5m.

The gravels are mainly rounded gravel, and the maximum size is 20cm diameter.
The sand layers are poorly compacted and consolidated. Also those are composed of moderately sorted grains which are fine to very coarse grains and sub-rounded to rounded grains.

PHOTO 10.1-1 OUTCROP OF TIGATTO TERRACE GRAVEL

(c) Bunawan Limestone

The Bunawan Limestone is the raised coralline limestone and coral breccias found in Matina Hill and Barangay Bunawan. This limestone is porous and cream color.

Incidentally, Bunawan Limestone is the equivalent of Samal Limestone in the published geologic map of the Mines and Geosciences Bureau.

PHOTO 10.1-2 OUTCROP OF TIGATTO BUNAWAN LIMESTONE

(d) Apo Volcanic Complex

The Apo Volcanic Complex which was created in the Pleistocene is composed of basalt, andesite, pyroclastic rocks, pyroclastic flows and volcanic mud flows.

Incidentally, because the basaltic flows are overlain by more recent andesitic flows, the outcrop of basalt of Apo Volcanic Complex cannot practically be found.

The Apo Volcanic Complex can be separated into three groups which are Apo Volcanics, Talomo Volcanics and Apo-Talomo Volcanic Cones.

The Apo Volcanics are dominantly the intercalated pyroclastics and volcaniclastics with lenses of volcanic ash which are generally occupy the broad volcanic footslopes. It is thought the repetitive eruption episodes cause the ejecta deposition of wide area.

The Talomo Volcanics are composed of andesitic-basaltic volcanic flows with intercalated pyroclastics, tuff and volcaniclastics.

Also, the Apo-Talomo Volcanic Cones consist of andesitic-dacitic volcanic lava.

PHOTO 10.1-3 OUTCROP OF PYROCLASTIC FLOW IN APO VOLCANIC COMPLEX

(e) Mandog Formation

The Mandog Formation is composed of alternation layers of consolidated sand and clay with minor gravels. It unconformably overlies the Masuhi Formation.

In addition, the Mandog Formation is folded, and the fold of thin sequence of interbedded sand and clay with gravels is found at outcrops.

PHOTO 10.1-4 OUTCROP OF SAND GRAVEL IN MANDOG FORMATION

(f) Masuhi Formation

The Masuhi Formation is composed of interbedded sandstone and mudstone (claystone/siltstone) with lenses of conglomerate. It is the basement rock of the section of the proposed bypass road.

The Masuhi Formation is thought the marine sediment of Late Miocene-Pliocene. The range of thickness is estimated from 200-250m.

PHOTO 10.1-5 OUTCROP OF MUDSTONE IN MASUHI FORMATION

3) Regional Tectonism

The prominence of lineaments (rock discontinuities such as joints, fractures, beddings, faults) is related to the regional tectonic setting.

The proposed bypass road is located at the southern end of the Agusan-Davao Basin. It is north-south trending elongated basin of 350 km located between the Pacific Cordillera and the Central Mindanao Cordillera.

In Mindanao, the Central Mindanao Cordillera, Agusan-Davao Basin and Pacific Cordillera are part of the Philippine arc. The Central Mindanao Cordillera is thrust westwards over the Lanao-Bukidnon Highlands. Also the Pacific Cordillera is thrust westwards over the Agusan Davao Basin.

The Saranggani Ridge, Davao Gulf and Pujada Peninsula respectively correspond to the volcanic arc, forearc basin and forearc of the Saranggani arc. Saranggani Ridge is convex to the east and is being thrust eastwards over the Davao Gulf.

4) Geo-Structure and Seismicity

The Davao City where the proposed bypass road is located is within a region that is tectonically, seismically and volcanically active. There are several active faults in the region according to **Figure 10.1-2** mapped by PHIVOLCS. Incidentally by the definition, an active fault is one that has moved during the last 10,000 years.

The active or potentially active faults within the 100km radius of the proposed project site are as follows:

(a) Philippine Fault

The Philippine Fault is an active left lateral strike slip fault that cuts across the entire length of the Philippine archipelago over a distance of 1,200 km. The southern segment of the Philippine Fault cuts across eastern Mindanao.

The Davao portion of the fault is associated with a seismic fault where stress is building up and is not being released. Despite its low level of seismic activity, the risk of a major earthquake occurring is actually higher.

The studies done by Quebral (1994) revealed the Philippine fault in the southeastern Mindanao have numerous splay faults not reflected in the PHIVOLCS map (Refer **Figure 10.1-2**).

(b) Davao Gulf Reverse Faults

The faults within the Davao Gulf are important tectonic feature it is not reflected in the PHIVOLCS map. By Wells and Coppersmith empirical relation between fault length and magnitude (1994), these faults can generate approximately 7.2 magnitude earthquake, and become a potential near-source of the tsunami generator against Davao City.

The coastal areas around the Davao Gulf have experienced historical events as in the 17 August 1976 Moro (Davao) Gulf earthquake with computed magnitude of 7.9 in the Richter Scale. The generated tsunami by this earthquake was about 6 meters high that inundated the coastal areas of Davao City. Moreover, It has a velocity of 72km/h and rushed up to 500m inland, leaving damages of 3,564 dead, 1,502 missing , 8,256 wounded, and 12, 183 families homeless (Cabanlit, 2010).

(c) Philippine Trench

The Philippine Trench is one of the two subduction zones that bound the Philippines. It runs a few kilometers offshore of the eastern coastline where the West Philippine Sea plate is being consumed along the west-dipping Philippine Trench. Also, the Philippine Trench is the most seismically active earthquake generator in the Philippines, hosting a big percentage of earthquakes that happened in Mindanao (Cabanlit 2010).

(d) Central Mindanao Fault

The Mindanao Central Cordillera is thrust westwards over the Lanao-Bukidnon Highlands along the Central Mindanao Fault which is north-south trending fault that extends all to Ginoog Bay in the north. In the south, the Central Mindanao Fault runs through the pyroclastic apron of Mount Talomo which is a major Quaternary stratovolcano.

The moderate earthquakes and focal mechanism solutions over the Bukidnon area suggest that the fault might still be active.

(e) Diwata Fault

The north-south trending escarpment formed by the Diwata Fault separates the Pacific Cordillera of Diwata area from the Agusan Davao Basin. This fault is not a splay fault of the Philippine Fault. It is a thrust fault that the cordillera is thrust westwards over the basin.

(f) Saranggani Thrust

The Saranggani Ridge is asymmetrical with a steep eastern flank and a gentle western flank. The anticline, which is convex to the east, is being thrust to the east along an assumed Saranggani Thrust which is associated with earthquake epicenters and thrust focal mechanism solutions.

(g) Daguma Fault

The Daguma Fault, characterized by a prominent NW-SE trending escarpment, separates the Daguma Range from the Cotabato Basin. The 165 kilometer fault, characterized by a prominent NW-SE trending, NE-facing escarpment, is a normal fault with the Daguma Range being on the up-thrown side and the Cotabato Basin being on the down-thrown side. Normal faulting may be attributed to back arc extension of the Cotabato Trench.

There are seismic and geologic indications that the fault is active like seismic reflection profiles and the sharp morphology (Quebral 1993). Along its southeastern end, the fault cuts Quaternary limestone.

5) Considerations for Seismic Design

The near faults that can generate large-scale magnitude earthquake in the area of the proposed bypass road are the Philippine Fault in the northeastern portion and the Davao Gulf Reverse Faults in the southwestern. The Philippine Fault is situated at approximate distances of 5-10km northeast from the north end point of the bypass road. Also, the Davao Gulf Reverse Faults are situated at southern from the vicinity of Samal Island.

Therefore, the earthquake by these active faults should be considered in designing the main structures such as bridges.

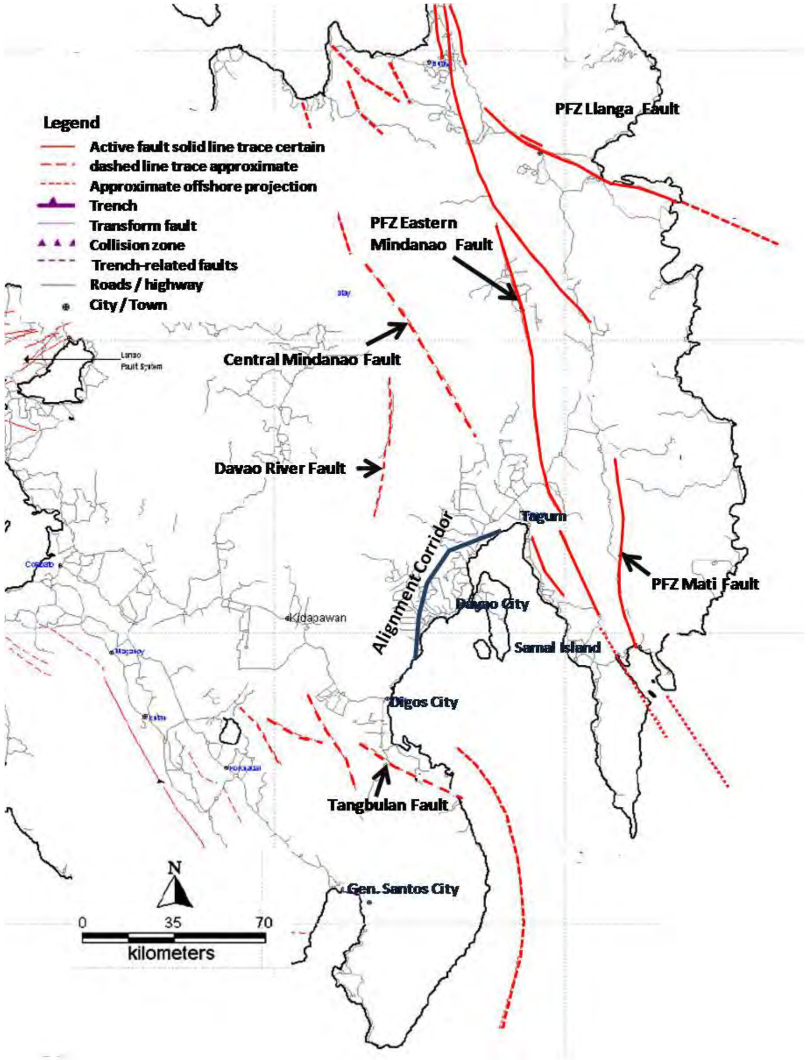
The National Structural Code of the Philippines (NSCP1997) prescribes a value of the design ground acceleration. The value of the design ground acceleration is 0.4g (A=0.4), because the site of the bypass road is situated in the Seismic Zone 4.

6) Potential of Liquefaction

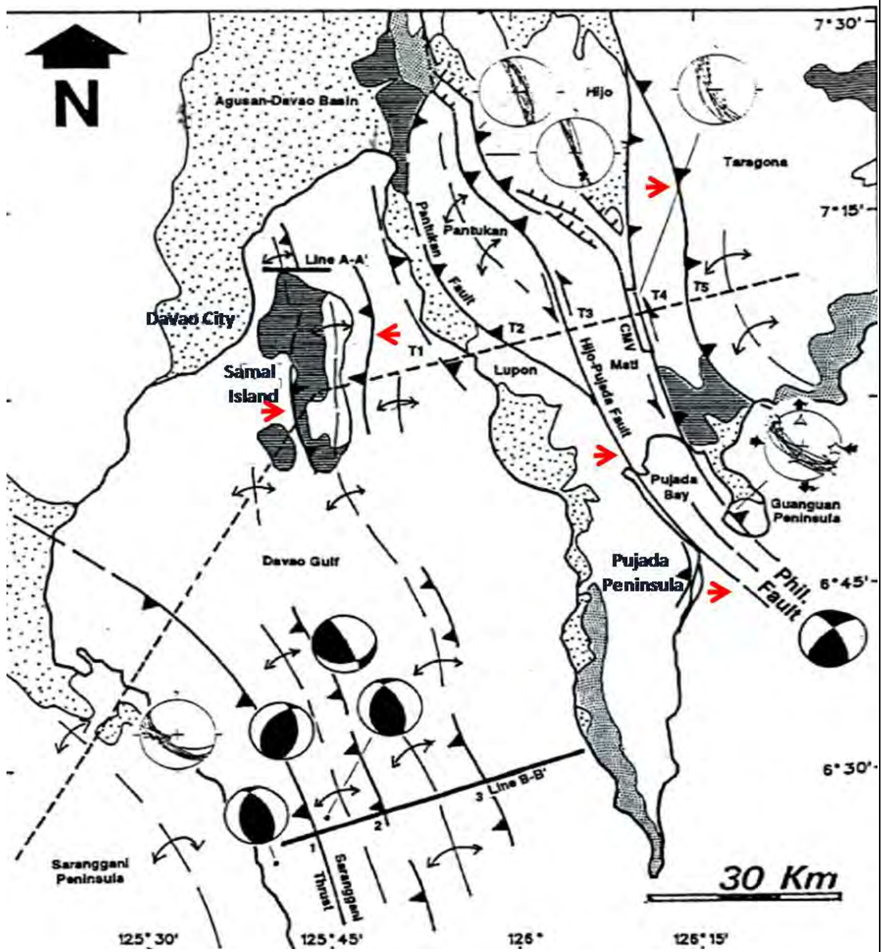
The lowlands of the area of along Davao River and the end point area of the by-pass road (northeastern area) are formed by the alluvium. The alluvium is composed of alternation layers of cohesive soil and sandy soil which are deposits of Holocene (Recent).

The thickness of alluvium along the Davao River is 15-20m, and consisting mainly of cohesive soil. Therefore, a possibility of the consolidation settlement is low, but there is a possibility of liquefaction during the earthquake.

The lowland of the end point area is alluvial lowland formed by Bunawan River (including Tagurot River, Lacanon River) and Lasang River (including Maduao River), the thickness of alluvium is very thick at 40-60m. So, there is a possibility which both the consolidation settlement and the liquefaction would be a problem. Particularly, since the ground of this lowland is mainly a thick soft ground of cohesive soil, there is a possibility which the consolidation settlement occurs over a long period of time, when the embankment is carried out. Therefore, the considerations such as avoidance of the high embankment and an examination of the negative skin friction at the design of pile foundation are necessary when the bypass road is constructed.



Map Showing Active Fault and Trenches (From PHIVOLCS)



Structural map of the southeast Mindanao with focal mechanism, Legend: Recent (dotted) Pleistocene (dashed, Late Miocene (densely dotted). Red arrows points to fault lines not reflected in PHIVOLCS map. From Quebral 1994

FIGURE 10.1-2 MAPS SHOWING ACTIVE FAULTS IN SOUTHEASTERN MINDANAO

(2) Investigation Items and Locations

Investigation items and quantities of the geological survey are shown in **Table 10.1-3**.
The locations conducted investigations are shown in **Figure 10.1-3**, and **Figure 10.1-4**.
Test pit and auger boring was conducted from 6+300 to 17+400 and from 35+500 to 44+600.

TABLE 10.1-3 INVESTIGATION ITEMS AND QUANTITIES

Items		Unit	Bridge site	Tunnel section	Low embankment section	Total
Boring	Number of boreholes	holes	20	8	-	28
	Total Length	m	548	585	-	1,075
Standard Penetration Test		each	548	290	-	790
Seismic Velocity Logging		each	-	137	-	137
Test pit		each	-	-	20	20
Auger boring		each	-	-	20	20
Laboratory Test of Soil and Rock Samples	Specific Gravity of Soil	samples	60	40	40	140
	Natural Moisture Content of Soil	samples	60	40	40	140
	Grain Size Analysis of Soil	samples	60	40	40	140
	Atterberg Limits of Soil	samples	30	20	20	70
	Unit Weight (Wet Density) of Rock	samples	-	20	-	20
	Axial compression test of Rock	samples	-	20	-	20
	Auger-boring	samples	-	-	20	20

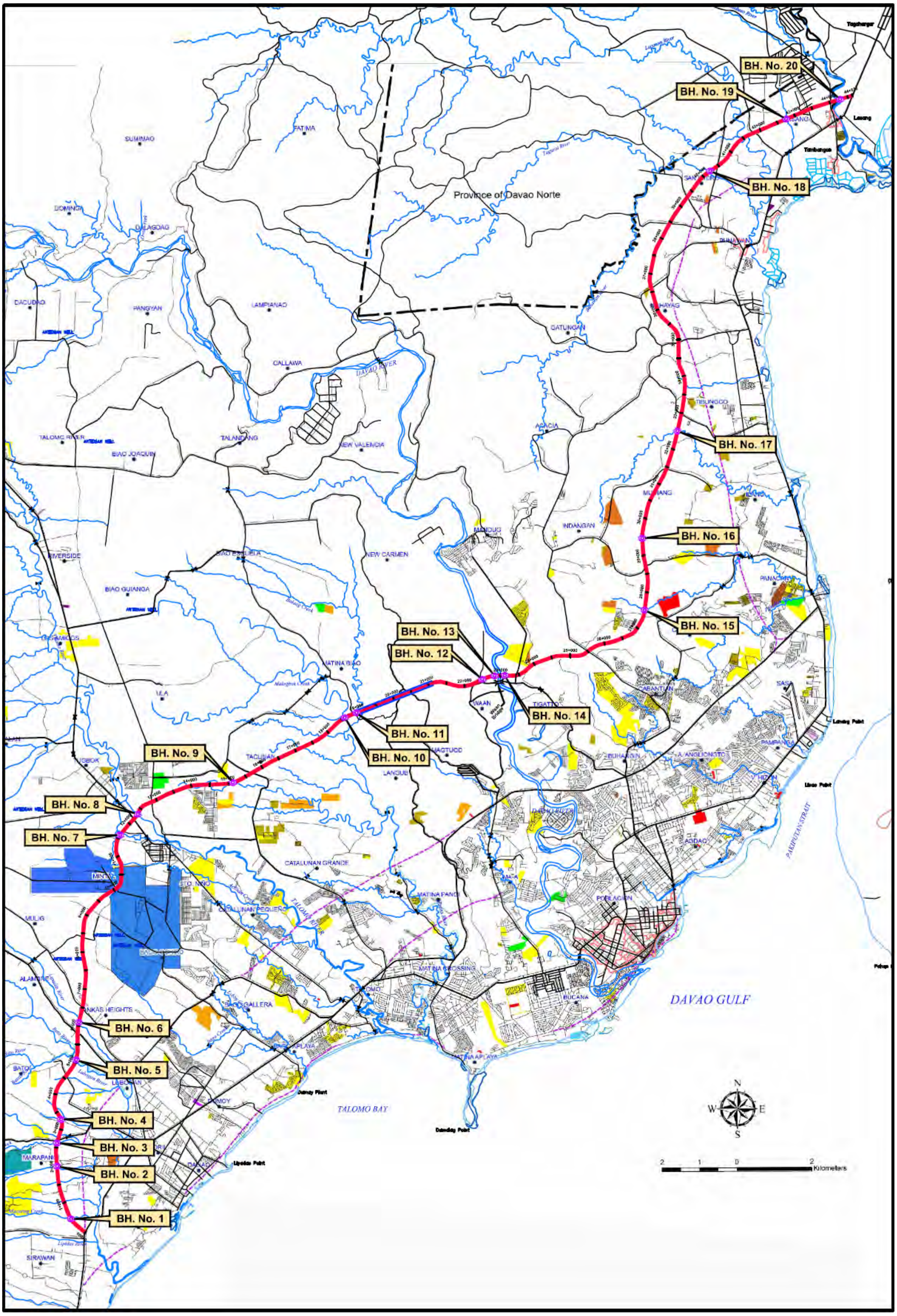


FIGURE 10.1-3 BRIDGE SITE BORING LOCATION MAP

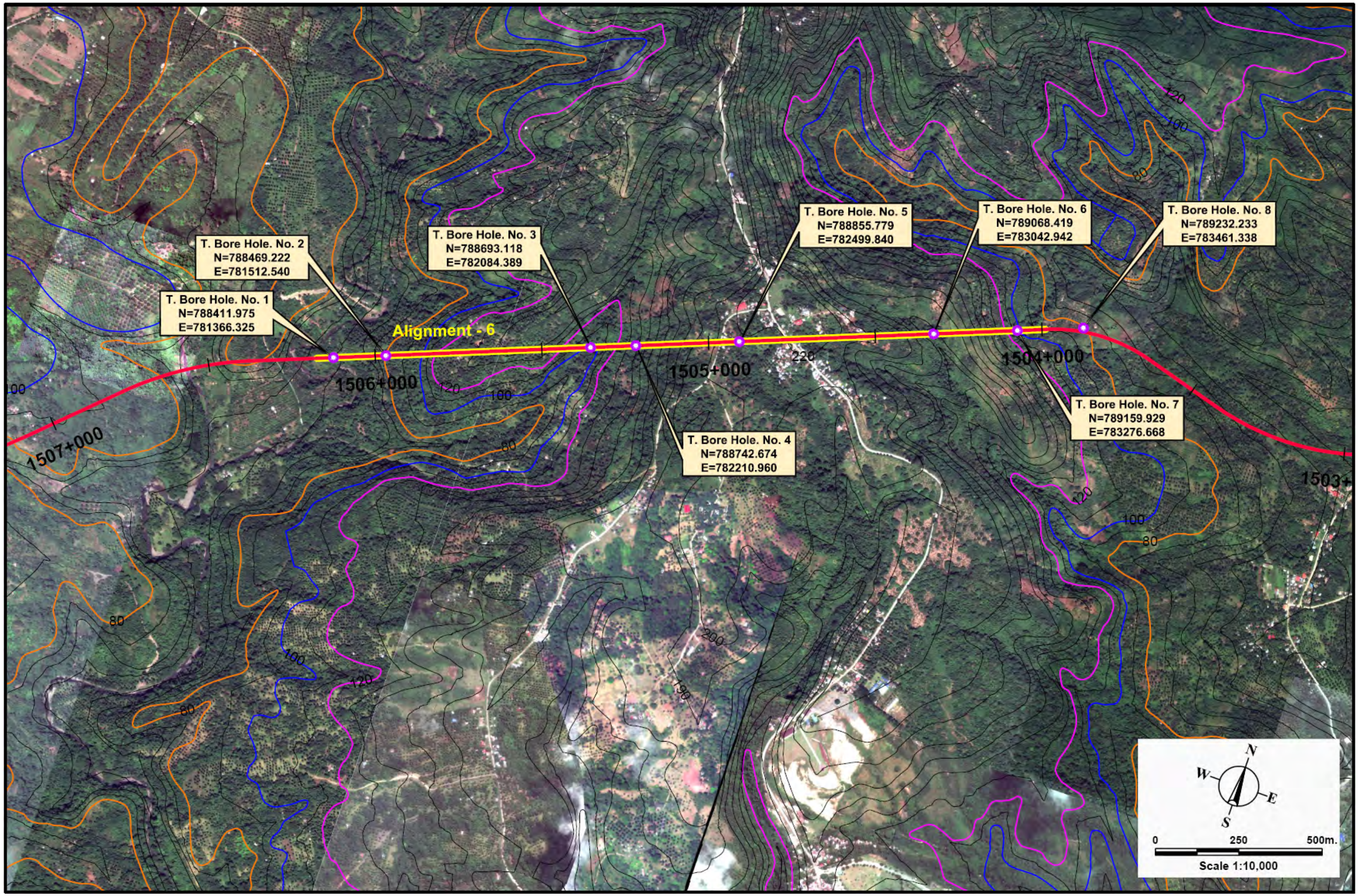


FIGURE 10.1-4 TUNNEL SECTION BORING LOCATION MAP

(3) Investigative Method

1) Boring

The boring which is non-core for soils and all-core drilling for rocks was performed by rotary boring machine. Drilling-diameter had been the φ66mm or more which is possible in-situ tests (Standard Penetration Test and Seismic Velocity Logging).

2) Standard Penetration Test

The standard penetration test was carried out according to ASTM D-1586 at intervals of 1 meter (depth) in the borehole.

3) Seismic Velocity Logging

The velocity logging was performed according to ASTM D-7400 by the down-hole method at intervals of 2m (depth) in the boreholes of tunnel section. The measurement depth had been up to about 50m which is measurable depth of the down-hole method.

4) Test pit and Auger boring

Test pit and auger boring were carried out alternately at about 500-meter intervals at the low embankment section.

The test pits were excavated at sizes of 1 square meter with the depth of 1 meter in principle. And the soil samples for the laboratory tests of CBR tests and etc. were obtained from the test pits.

The auger boring was drilled until 1 meter depth in principle.

5) Laboratory Test of Soil and Rock Samples

Laboratory test of soil and rock samples were carried out on the basis of the standards shown in **Table 10.1-4**.

TABLE 10.1-4 APPLIED STANDARDS FOR LABORATORY TEST

No.	Test Items	Ref. standard No.
1	Specific Gravity of Soil	ASTM D-854
2	Natural Moisture Content of Soil	ASTM D-2216
3	Grain Size Analysis of Soil	ASTM D- 422
4	Atterberg Limits of Soil	ASTM D-4318
5	Soil Description and Classification	ASTM D-2487
6	Unit Weight (Wet Density) of Rock	BS 1377-part 2-7
7	Axial compression test of Rock	ASTM D-2938
8	CBR (California Bearing Ratio) Test	ASTM D-1883

(4) Summary of Results and Findings

1) Bridge Site Investigation Results

Boring, standard penetration test and laboratory test of soil samples were carried out at 20 locations shown in **Figure 10.1-3**, as the investigation of bridge sites. Depths of boring at BH-18, 19 and 20 are more than 35m. These are has a thick presence of very soft to very loose fluvial sediments. BH-1 to BH-17 shows a favorable subsurface condition.

Summary of the survey results are shown in **Table 10.1-5**.

TABLE 10.1-5 SUMMARY OF BRIDGE SITE INVESTIGATION RESULTS

Boring No.	Coordinates		Elevation (GL) (m)	Drilled Depth (GL-m)	Ground Water Level (GL-m)	Depth of Bearing Stratum (GL-m)
	Northing (X-coordinate)	Easting (Y-coordinate)				
BH-1	774830.341	773771.625	41.890	25.0	16.00	2.0
BH-2	776217.359	773539.610	41.298	25.0	15.60	2.0
BH-3	776868.665	773514.471	48.578	25.0	13.80	1.0
BH-4	777509.505	773806.947	50.374	25.0	16.80	3.0
BH-5	779022.566	773882.248	84.316	25.3	12.35	2.0
BH-6	780080.905	774063.112	110.504	25.0	7.50	6.0
BH-7	785049.379	775121.286	139.959	25.0	9.00	6.0
BH-8	785686.768	775691.242	139.856	25.0	18.70	9.0
BH-9	786504.879	777985.845	144.662	10.0	-	5.0
BH-10	788237.480	781195.323	82.558	25.3	13.80	2.0
BH-11	788338.456	781413.040	44.994	25.3	3.15	3.0
BH-12	789242.109	784737.284	12.360	27.1	3.80	22.0
BH-13	789355.205	785066.731	12.510	30.3	5.00	16.0
BH-14	789376.769	785365.964	11.150	25.0	5.60	11.0
BH-15	791115.132	789076.432	30.083	10.3	8.20	4.0
BH-16	792974.033	789000.648	68.132	8.3	4.20	4.2
BH-17	795964.260	789899.020	26.100	18.4	1.00	14.0
BH-18	802794.290	790816.630	11.020	45.45	3.60	35.0
BH-19	804205.502	792995.520	7.171	57.45	1.30	40.0
BH-20	804700.925	794328.247	5.215	65.45	5.60	61.0

Note: - In principle, "Depth of Bearing Stratum" was determined at the top of layer which is consecutive N-value of 20 or more in the case of cohesive soil layer, it is consecutive N-value of 30 or more in case of the sandy soil layer.

2) Tunnel Section Investigation Results

Boring, standard penetration test, seismic velocity logging and laboratory test of soil and rock samples were carried out at 8 locations shown in **Figure 10.1-4**, as the investigation of tunnel section. Summary of the survey results are shown in **Table 10.1-6**. And based on the boring result, the uppermost material consists of sand and clay layer, with recorded blow counts between 14<N<45 in the upper stretches of layer and hitting practical refusals towards the bottom (60>N). This is then followed by a thick sequence of bedrock formation describe in the logs as claystone/mudstone.

P-wave velocity of mudstone, silt, and sandstone in this area shows common figures, ranging 1,200 ~ 1,800 m/sec. Based on P-wave test result, these layers is classified as soft rock layer. It is assumed that there is no aquifer layer between the surface and tunnel plan layer based on the result of the P-wave velocity 1,500 m/sec. So special counter measures shall not be required for underground water of tunnel construction.

The geological profile of tunnel section is shown in **Figure 10.1-5**.

TABLE 10.1-6 SUMMARY OF TUNNEL SECTION INVESTIGATION RESULTS

Boring No.	Coordinates		Elevation (GL) (m)	Drilled Depth (GL-m)	Tunnel Planning Depth (TPD) (GL-m)	P-wave Velocity of TPD (km/sec)
	Northing (X-coordinate)	Easting (Y-coordinate)				
TBH-1	788349.714	781474.675	58.214	30.0	-	-
TBH-2	788429.558	781609.701	83.309	65.0	14.0～21.0	1.2～1.4
TBH-3	788692.269	782105.384	144.659	35.0	74.0～81.0	0.7
TBH-4	788740.799	782314.508	139.256	80.0	66.0～75.0	1.6
TBH-5	788818.141	782623.423	213.658	160.0	141.0～148.0	-
TBH-6	788987.929	783133.111	191.716	130.0	120.0～127.0	1.1～1.2
TBH-7	789107.554	783498.885	115.009	55.0	46.0～53.0	1.2～1.8
TBH-8	789241.484	783565.112	85.466	30.0	17.0～24.0	0.6～0.9

Note: - "Ground water level in boreholes" was not determined because the geological feature of the boring site is mainly composed of mudstone (it is not an aquifer) of low permeability.
- "The depth from top to bottom" of the tunnel is shown at "Tunnel Planning Depth" in the table.

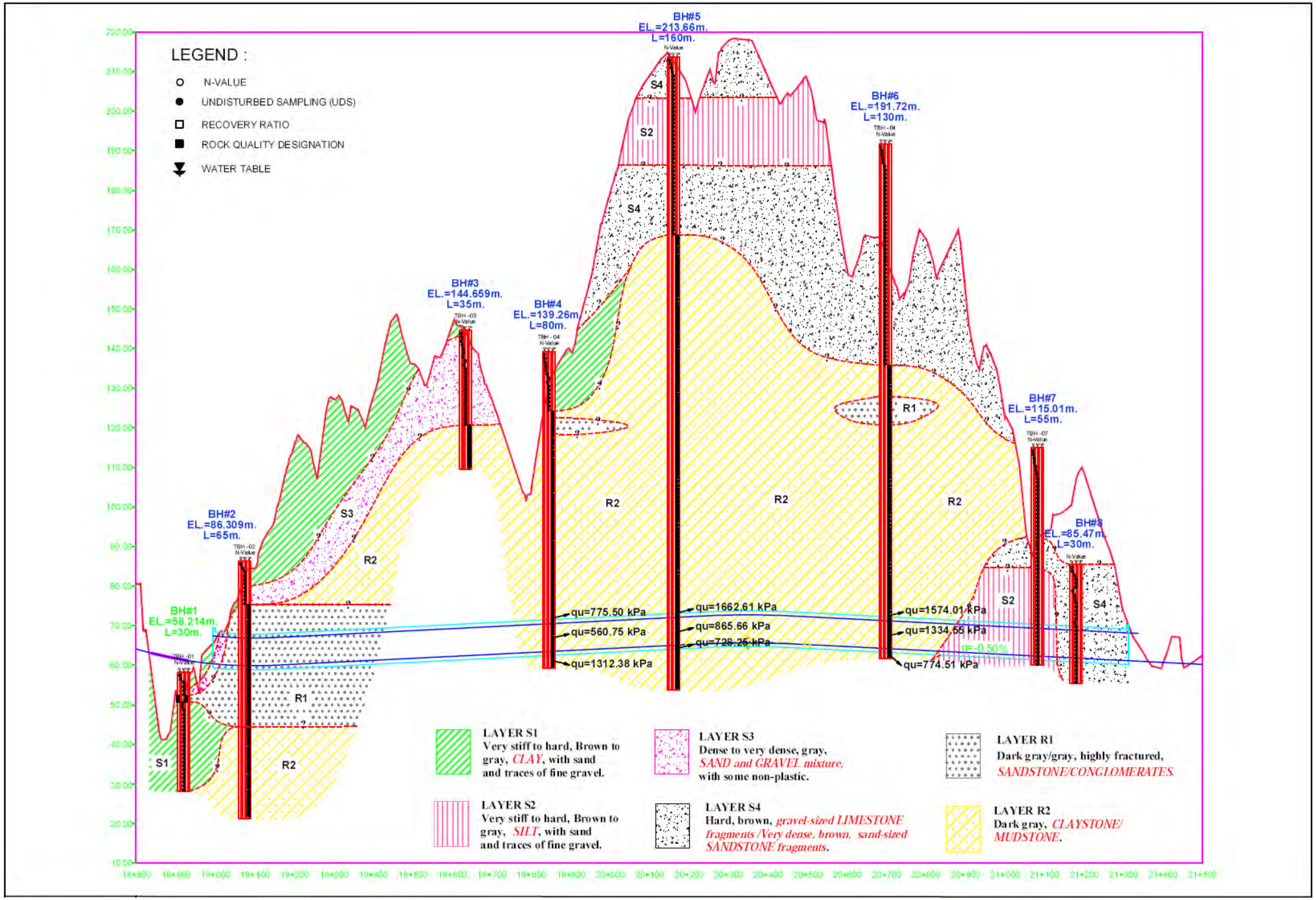


FIGURE 10.1-5 GEOLOGICAL PROFILE OF TUNNEL SECTION

3) Low Embankment Section Investigation Results

Laboratory test (physical test, CBR test) of soil samples taken at each location were carried out. Based on the field and laboratory test results of the twenty (20) test pits and twenty (20) auger holes, the excavated soils taken at the uppermost 1.2 to 2.0 meters depth mainly consisted of cohesive materials described as clay, with some content of sand. Summary of the survey results are shown in **Table 10.1-7**.

TABLE 10.1-7 SUMMARY OF LOW EMBANKMENT SECTION INVESTIGATION RESULTS

Test-pit				Auger-boring		
TP No.	Survey Depth (m)	Soil Description	CBR (%) @95% MDD	AB No.	Survey Depth (m)	Soil Description
TP-1 6+300	0 – 1.00	Clay w/ sand & gravel	11.0	AB-1 6+800	0-1.00	Gray, CLAY, medium plastic, with sand.
TP-2 7+300	0 – 1.00	Clay	3.1	AB-2 7+800	0-0.70 / 0.70-1.00	Brown, CLAY, with sand. / Brown, CLAY, medium plastic, with sand.
TP-3 8+300	0.80 – 1.00	Clay	3.7	AB-3 8+800	0-1.00	Brown, CLAY, medium plastic, with sand.
TP-4 9+400	0.20 – 1.00	Clay	3.3	AB-4 9+800	0-1.00	Brown, sandy CLAY, medium plastic.
TP-5 10+200	0.60 – 1.00	Clay	3.1	AB-5 10+800	0-0.40	Brown, CLAY, high plastic.
TP-6 11+300	0.30 – 1.00	Clay	2.8	AB-6 11+800	0-1.00	Dark brown, silty CLAY, slightly plastic, with sand.
TP-7 12+400	0 – 1.00	Clay w/ sand	7.0	AB-7 12+800	0-1.00	Dark brown, sandy CLAY, medium plastic.
TP-8 13+300	0 – 1.00	Clay w/ sand & gravel	8.8	AB-8 13+800	0-0.20 / 0.20-0.50	Brown, CLAY, with gravel and boulders./ Gray, silty CLAY, medium plastic, with sand and fine gravel.
TP-9 14+200	0.70 – 1.00	Clay	5.6	AB-9 14+800	0-0.90 / 0.90-1.00	Dark brown, CLAY, with some sand and fine gravel. / Gray, silty CLAY, medium plastic, with sand and fine gravel.
TP-10 15+600	0.30 – 1.00	Clay	3.6	AB-10 16+500	0-0.30 / 0.30-1.00	Brown, silty CLAY, with traces of sand. Brown, CLAY, high plastic, with sand.
TP-11 17+400	0 – 1.00	Clayey Gravel	15.0	AB-11 35+500	0-0.30 / 0.30-1.00	Dark brown, CLAY / Brown, CLAY, high plastic, with sand.
TP-12 36+000	0.60 – 1.00	Clay	4.4	AB-12 36+500	0-0.15 / 0.15-1.00	Brown, CLAY, with some fine gravel./ Brown, CLAY, high plastic, with sand.

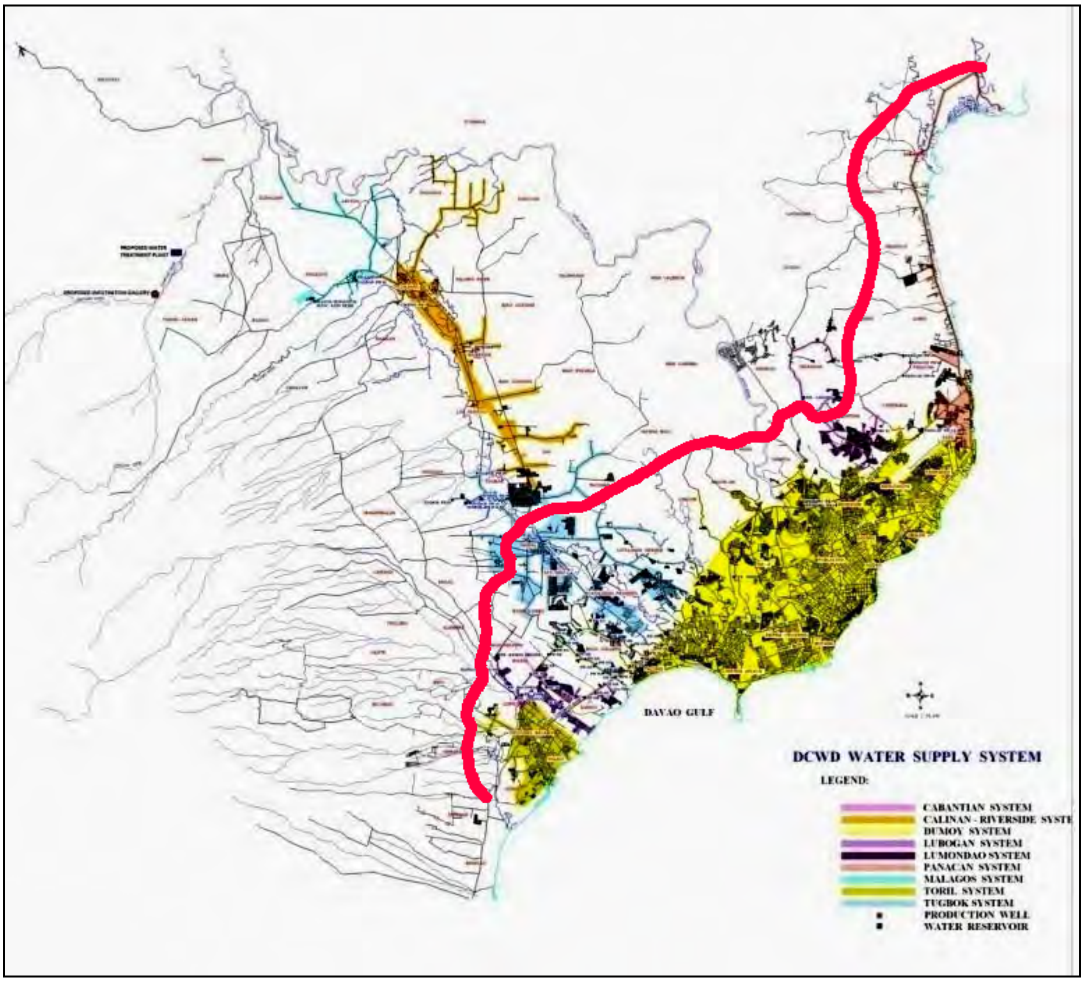
Test-pit				Auger-boring		
TP No.	Survey Depth (m)	Soil Description	CBR (%) @95% MDD	AB No.	Survey Depth (m)	Soil Description
TP-13 36+900	0.60 – 1.00	Clay	5.2	AB-13 37+400	0-0.90 / 0.90-1.00	Gray, CLAY, high plastic, with fine gravel./ Gray, CLAY, high plastic, with sand.
TP-14 37+900	0.40 – 0.95	Clay w/ limestone fragments	11.0	AB-14 38+400	0-0.30 / 0.30-1.00	Dark gray, silty CLAY, slightly plastic,with fine gravel and sand./ Brown, silty CLAY, medium plastic, with sand and fine gravel.
TP-15 39+000	0.25 – 1.00	Clay	3.6	AB-15 39+700	0-0.15 / 0.15-1.00	Dark gray, sandy CLAY./ Brown, sandy CLAY, medium plastic.
TP-16 40+200	0.70 – 1.00	Sand & Clay	9.8	AB-16 40+700	0-0.10 / 0.10-0.90 / 0.90-1.00	Brownish gray, CLAY, with sand./ Light brown, CLAY, medium plastic, with sand./ Light brown, CLAY, medium plastic, with sand.
TP-17 41+200	0 – 1.00	Clay	5.2	AB-17 41+700	0-1.00	Brownish gray, silty CLAY, medium plastic, with sand.
TP-18 42+200	0 – 1.00	Clay	6.5	AB-18 42+700	0-0.15 / 0.15-1.00	Dark brown, silty CLAY./ Light brown, clayey SAND, slightly plastic
TP-19 43+200	0 – 1.00	Clay	5.8	AB-19 43+700	0-1.00	Brown, silty CLAY, medium plastic, with sand.
TP-20 44+200	0 – 1.00	Sand & non-plastic Silt	17.0	AB-20 44+600	0-1.00	Brown, silty CLAY, medium plastic, with sand.

Source: JICA Study Team

10.1.4 Other Geo-technical Information

(1) Surface Water and Groundwater

The data of the surface water and groundwater in Davao City were gathered from studies done by Asian Development Bank (2012), MGB Region XI and those from Davao City Water District. The Davao City Water District (DCWD) is the country's largest district since its creation in 1973. It covers about 106 barangays (about 58% of the total 182 barangays within its jurisdiction). DCWD manages nine water supply systems, which consists of the Cabantian, Calinan, Dumoy, Lubogan, Lumandao, Malagos, Panacan, Toril and Tugbok as shown **Figure 10.1-6**.



Source: Final Report- Feasibility Study on the Use and Development of Surface Water of Tamugan River, June 2010, DCWD

FIGURE 10.1-6 DCWD SERVICE AREAS

The current raw water source of DCWD is not sufficient to meet the increasing demand. The groundwater source is concentrated at Barangay Dumoy located at the skirts of Mount Apo and Mount Talomo, where DCWD operates more than 30 deep wells. Also only small amount of surface water, the water of 36 liters/sec is withdrawn from the Malagos Creek it is a small tributary of the Davao River.

The capacities of the nine systems serving the overall DCWD service areas are summarized in **Table 10.1-8**. As some of the barangays are served by more than one of the water sub-systems and the total of served barangays are more than 106, as indicated in the table. As of 2012, the number of active connections are 174,108 consisting of 167,780 domestic connections, 5,698 commercial and bulk consumers and 630 government consumers.

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Although the data in **Table 10.1-8** is the data of 2010, as of 2012, the numbers of active connections are increased 174,108 consisting of 167,780 domestic connections, 5,698 commercial and bulk consumers and 630 government consumers.

TABLE 10.1-8 DCWD SERVICE AREA AND CONNECTIONS

No.	Water Supply System	Number of Barangays Served	Population Served	Number of Connections		
				Domestic	Commercial and Bulk	Government
1	Cabantian	3	30,128	6,017	30	11
2	Calinan	11	19,873	3,950	101	23
3	Lubogan	6	27,051	5,406	14	5
4	Lumandao	1	56	11	1	0
5	Dumoy	71	553,175	109,584	4,825	428
6	Malagos	3	3,973	793	2	5
7	Panacan	6	32,734	6,516	123	29
8	Toril	8	32,836	6,527	170	33
9	Tugbok	10	84,056	16,763	145	95
Total		119	783,882	155,567	5,411	629

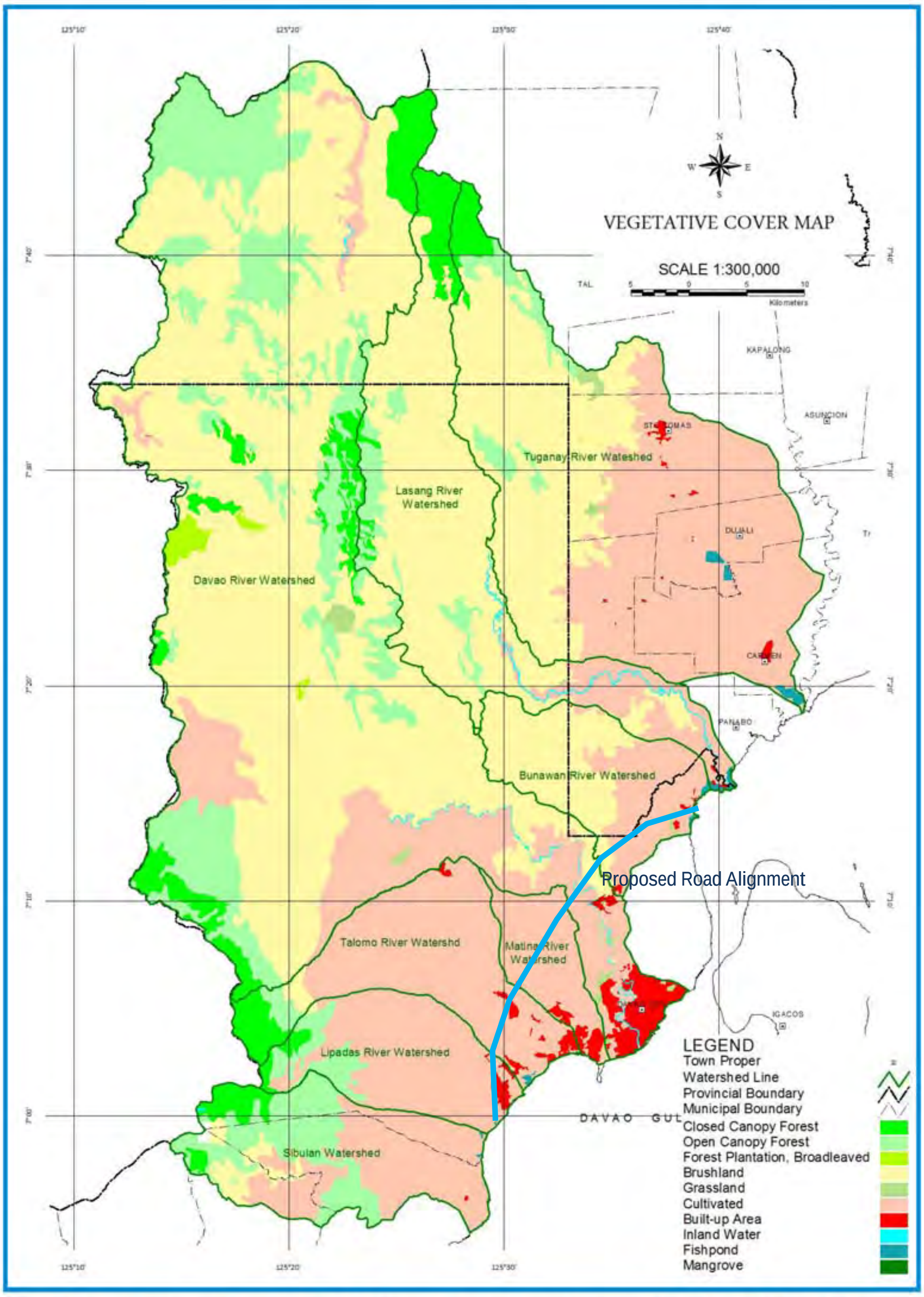
Source: Final Report- Feasibility Study on the Use and Development of Surface Water of Tamugan River, June 2010, DCWD

The raw water will only supply 43% of Davao City's projected population of 2.5 million in 2030 in the capacity without expansion of the water source. There are already some problems as polluted coastal aquifers, decreasing levels of groundwater, increasing land subsidence and saltwater intrusion due to over-extraction of ground water. And these problems compel the need to tap reliable surface water as supply sources.

DCWD intends to shift from groundwater dependent to surface water first. But a move to secure the future source of water for the city is late, due to fear of groundwater contamination by pesticide from the extensive banana plantations and farms on the skirts of Mount Talomo and along the Davao River.

1) Watershed of Surface Water

Davao City's political boundaries overlap eight different watersheds (refer **Figure 10.1-7**) where the Talomo-Lipadas watershed is a major source of drinking water. Ninety nine percent (99%) of the urban population of Davao City get their drinking water from within these river basins.



Source: City Planning and Development Office, Davao City

FIGURE 10.1-7 MAP SHOWING VEGETATION COVER IN 8 WATERSHEDS WITHIN THE POLITICAL BOUNDARY OF DAVAO CITY

Table 10.1-9 provides a summary of the area of the river basins and the area percentage within the political boundary of the Davao city.

TABLE 10.1-9 SUMMARY OF AREA OF EIGHT RIVER BASINS THAT AREA WITHIN THE JURISDICTION OF DAVAO CITY

River Basin (RB)	Hectares in Davao City	% RB within the City	Total Hectares of 8 RB
Davao River	121,385	69%	175,776
Lasang	29,132	64%	45,390
Talomo	21,578	100%	21,578
Lipadas	16,796	100%	16,796
Bunawan	18,328	73%	25,213
Tuganay	18,120	24%	74,747
Sibulan	10,782	38%	28,213
Matina	7,879	100%	7,879
Total Area	244,000	62%	395,592

2) Groundwater Resources

Most of the water wells of DCWD are placed in Dumoy, and the rest of water wells are placed in Tugbok, Panacan, Toril, Dacoville, Batulosa, Lumondado, and Riverside. These wells have an average depth of 120-150 m.

The aquifers of groundwater in Davao City are recharged perennially by rainfall on the southern flanks of Mount Apo, Mount Tipolog and Mount Talomo. These areas are covered by highly porous pyroclastic materials and permeable highly fractured volcanics that receive and store sufficient groundwater to recharge the aquifers in the lowlands.

The aquifers in Davao City are classified based on rock types as below:

(a) Aquifer in Igneous Rock and Volcano clastics

Igneous rocks are poor aquifers with permeability confined along openings of fractures / fissures. Volcano clastics (e.g. pyroclastic flows, sandy tuff, tuff breccias and volcanic mud flows) are very porous and permeable, and there are natural features of very good aquifers.

(b) Aquifer in Sedimentary Rock

Groundwater flow in sedimentary rocks is influenced by the physical property, composition, lithology and faces. In general, coarse grained sedimentary rocks such as conglomerates and sandstones are good aquifers. But fine grained sedimentary rocks like mudstone, siltstone, or shale are poor aquifers due to very poor hydraulic permeability.

(c) Aquifer in Limestone

Limestone is excellent groundwater conveyor by the presence of cavities and caves. Coralline limestone in Davao City has a high percentage of openings that can hold high volume of groundwater. The downsides are the low filtration capacity and the property that is easy to be pollution.

(d) Aquifer in Unconsolidated Sediments

The unconsolidated sediments are mainly deposits of gravel, sand, silt and clay which are laid at the valley floor, alluvial and coastal plains. These are the materials produced by weathering and erosion of the bedrock.

In general, the sand layers of unconsolidated sediments are excellent and efficient aquifers. The porosity and permeability of sand layers are commonly high, but only to be reduced by infilling of fine fraction (silt and clay, very fine sand) between interstices of grains. Therefore, the porosity of sand layers is dependent on grain size, shape and grain-size distribution.

3) Dumoy Well Field

The Dumoy Well Field (Refer **Photo 10.1-6**) is in the southwest of Davao City and the main groundwater source for the DCWD. The well field is located at the foot slopes at the east of Mount Talamo blanketed by volcanic mud flow. The slopes of Mount Talamo serve as the watershed area for the deep aquifers while the shallow aquifers are recharged by the Talamo River. The Dumoy Field is approximately 8 km width and 13 km length along the coast of Talamo Bay. There are 30 wells operated by DCWD and several private industrial wells in the area. The production of each well is range of 1,617-4,700 liters/minute. And the well depth ranges from 90-152m.

PHOTO 10.1-6 THE WELL OF DUMOY WELL FIELD

4) Panacan Wells

The Panacan is located at about 5km northeast of Davao City where the Alluvium is underlain by the Mandug Formation and Bunawan Limestone.

In Panacan, there are two operating wells which average depth is 104m, and total production of the two wells is 2,000 liters/minute.

(2) Influence of Road Construction on Water Sources

The water source of the Davao City Water District (DCWD) is concentrated at the Dumoy Well Field located at the skirts of Mount Apo and Mount Talomo, and other water sources are the Panacan Wells and the Malagos Creek of a small tributary of the Davao River.

Because the water sources above are separated by 2-3km or more from the proposed bypass road alignment, the impact on the water source of the DCWD is not almost.

On the other hand, the neighboring area of the proposed tunnel section of the bypass road is not the service area of the DCWD. So the resident’s management wells and the stream water are used as water sources. The influence of tunnel excavation to these water sources cannot be explained in detail from the geological investigation results of this time. But it is estimated the influence is small because the bedrock of the tunnel excavation depth is mainly the mudstone with low permeability of the Masuhi Formation (There is not an aquifer). However, it is desirable to check in detail the influence to the groundwater by the monitoring during tunnel excavation.

10.2 DESIGN STANDARDS

10.2.1 Design Concept

The design concept is to provide a relative high speed road that allows a safe and efficient movement of traffic as a bypass road.

10.2.2 Geometric Design Standards

The following standard is mainly used as reference in Davao City Road.

- A Policy on Geometric Design of Highways and Streets, AASHTO 2011, 6th Edition
- Highway Safety Design Standards Part I Road Safety Design Manual, May 2004, DPWH
- Japan Road Association, Road Structure Ordinance, 2004.

(1) Design Speed

In accordance with Road Safety Design Manual (DPWH, 2004) as well as considering to the topographic condition, the recommended design speed is 60kph.

(2) Summary of Road Geometry

Geometry applied to the road design is summarized in **Table 10.2-1**.

TABLE 10.2-1 SUMMARY OF ROAD GEOMETRIC DESIGN STANDARD (DESIGN SPEED, 60KPH)

Item		Unit	Standard	Absolute Minimum	Remark
Design Speed		kph	60		
Design Vehicle		-	WB-15		
Stopping Sight Distance		m	85		Page 7-3, Table e7-1, AASHTO 2011
Passing Sight Distance		m	180		
1. Cross Section Elements					
Lane Width		m	3.5		Page 53, Table 16.1, DPWH Road Safety Design Manual
Outer shoulder Strip		m	3.0	2.5	
Number of Lanes		Nos.	2		
Normal Cross Slope		%	2		Page 7-4, AASHTO 2011
Maximum Super elevation	Flat	%	6		Page 53, Table 16.1, DPWH Road Safety Design Standard
	Rolling	%	8		
	Mountainous	%	10		
2. Horizontal Alignment					
Minimum Radius		m	123		Page 3-32, Table 3-7, AASHTO 2011, e=6%
Min. Transition Curve Length		m	50		JPN
Min. Radius not requiring Transition Curve		m	1,030		Page 3-45, Table 3-9, AASHTO 2011, cross slope, 2%)
Min. Radius not requiring Superelevation		m	2,000		JPN (cross slope, 2%)
		m	1,500		JPN (cross slope, 1.5%)
Superelevation Runoff			1/167		
3. Vertical Alignment					
Maximum Vertical Gradient	Flat	%	5		Page 7-4, Table 7-2, AASHTO 2011
	Rolling	%	6		
	Mountainous	%	8		

Item		Unit	Standard	Absolute Minimum	Remark
Minimum K value	Sag	%	18		Page 69, Table 16.4, DPWH Road Safety Design Manual
	Crest	%	11		
Minimum Radius	Sag	%	1,000		JPN
	Crest	%	1,400		
Min Vertical Curve Length		m	50		JPN
Max. Composition Grade		m	10.5		JPN
Critical Length of Grade		m	500 (6%)		JPN
		m	400 (7%)		JPN
		m	300 (8%)		JPN
4. Vertical Clearance					
Road		m	5.0		DPWH Requirement, 4.9 m (16 feet) clearance + α

(3) Vertical Clearance

The vertical clearance of the highway and crossing road shall be at least 5.2m (4.9m (16 feet) + 0.3m (overlay).

(4) Number of Lanes

Number of lanes is set as 2 lanes in accordance with the traffic demand. RROW will be secured at 40~60m considering 4 lanes widening in the future.

(5) Carriageway and Shoulder

The carriageway's width is 3.5m in accordance with Road Safety Manual (DPWH, 2004) .The shoulder is design as 2.5m. **Figure 10.2-1** shows the typical cross section.

(6) Stopping Distance

According to A Policy on Geometric Design of Highways and Streets (2011 AASHTO); the stopping distance for design speed of 60kph is 85m.

(7) Cross Fall Development

Superelevation of the carriageway shall be considered to accommodate recommendation of AASHTO 2011 as shown in **Table 10.2-2.** The maximum value of superelevation is 6% as guided in Road Safety Manual, 2004 in page 53. The superelevation rate for the applied design speed is shown in **Table 10.2-2.**

TABLE 10.2-2 MINIMUM RADII FOR DESIGN SUPERELEVATION RATES, EMAX=6%

METRIC

e (%)	V_d = 20 km/h R (m)	V_d = 30 km/h R (m)	V_d = 40 km/h R (m)	V_d = 50 km/h R (m)	V_d = 60 km/h R (m)	V_d = 70 km/h R (m)	V_d = 80 km/h R (m)	V_d = 90 km/h R (m)	V_d = 100 km/h R (m)	V_d = 110 km/h R (m)	V_d = 120 km/h R (m)	V_d = 130 km/h R (m)
1.5	194	421	738	1050	1440	1910	2360	2880	3510	4060	4770	5240
2.0	138	299	525	750	1030	1380	1710	2090	2560	2970	3510	3880
2.2	122	265	465	668	919	1230	1530	1680	2300	2670	3160	3500
2.4	109	236	415	599	825	1110	1380	1700	2080	2420	2870	3190
2.6	97	212	372	540	746	1000	1260	1540	1890	2210	2630	2930
2.8	87	190	334	488	676	910	1150	1410	1730	2020	2420	2700
3.0	78	170	300	443	615	831	1050	1290	1590	1870	2240	2510
3.2	70	152	269	402	561	761	959	1190	1470	1730	2080	2330
3.4	61	133	239	364	511	697	882	1100	1360	1600	1940	2180
3.6	51	113	206	329	465	640	813	1020	1260	1490	1810	2050
3.8	42	96	177	294	422	586	749	939	1170	1390	1700	1930
4.0	36	82	155	261	380	535	690	870	1090	1300	1590	1820
4.2	31	72	136	234	343	488	635	806	1010	1220	1500	1720
4.4	27	63	121	210	311	446	584	746	938	1140	1410	1630
4.6	24	56	108	190	283	408	538	692	873	1070	1330	1540
4.8	21	50	97	172	258	374	496	641	812	997	1260	1470
5.0	19	45	88	156	235	343	457	594	755	933	1190	1400
5.2	17	40	79	142	214	315	421	549	701	871	1120	1330
5.4	15	36	71	128	195	287	386	506	648	810	1060	1260
5.6	13	32	63	115	176	260	351	463	594	747	980	1190
5.8	11	28	56	102	156	232	315	416	537	679	900	1110
6.0	8	21	43	79	123	184	252	336	437	560	756	951

Source: AASHTO 2011

(8) Minimum Radius without Superelevation

When the curve radius is larger than R=1,030m, superelevation can be omitted in accordance with AASHTO 2011.

(9) Maximum Gradient

For the main alignment with design speed of 60kph, the maximum vertical gradient based on the Road Safety Manual (2004 DPWH) that could be applied are 6% (flat), 8% (rolling), and 10% (mountainous).

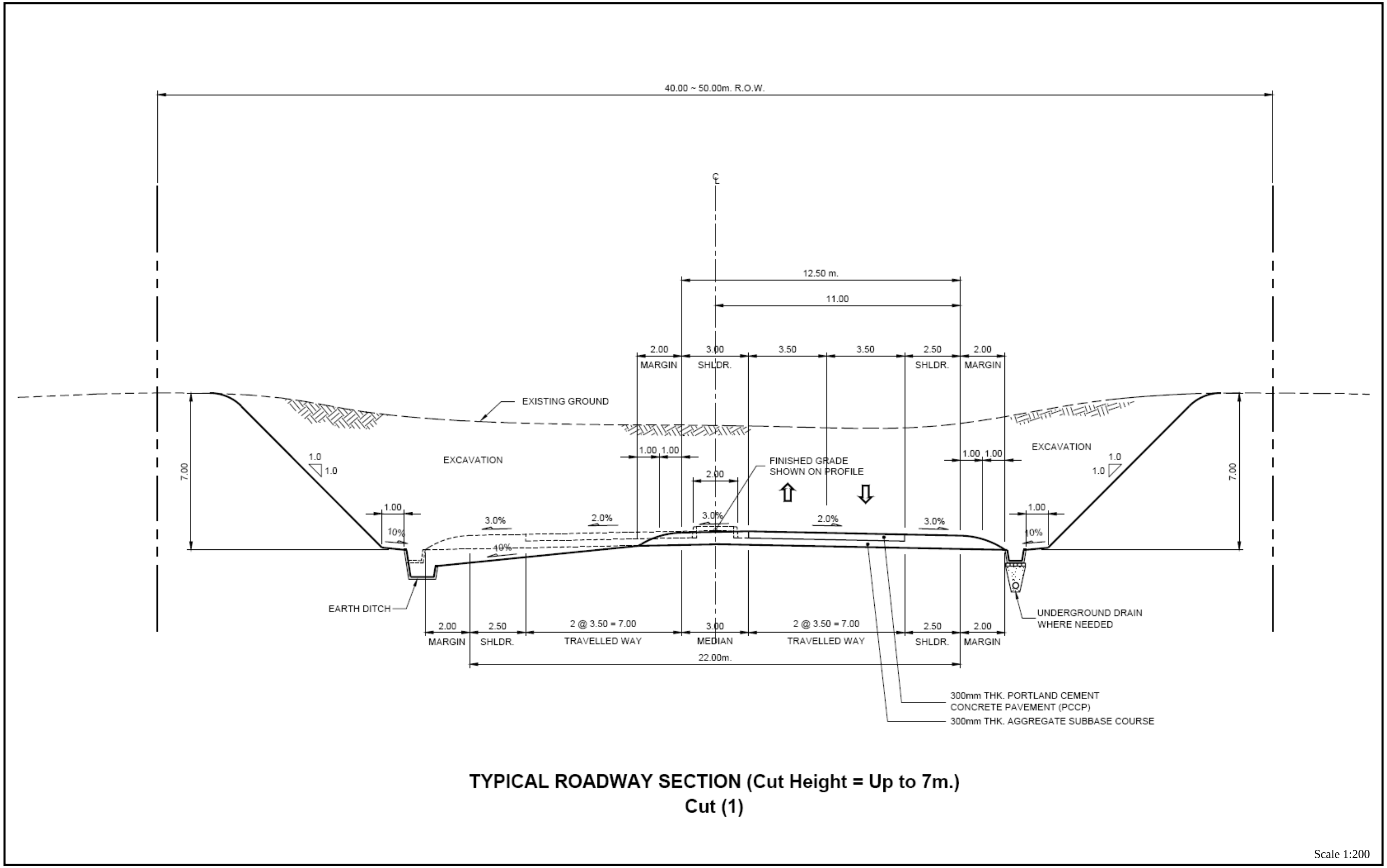
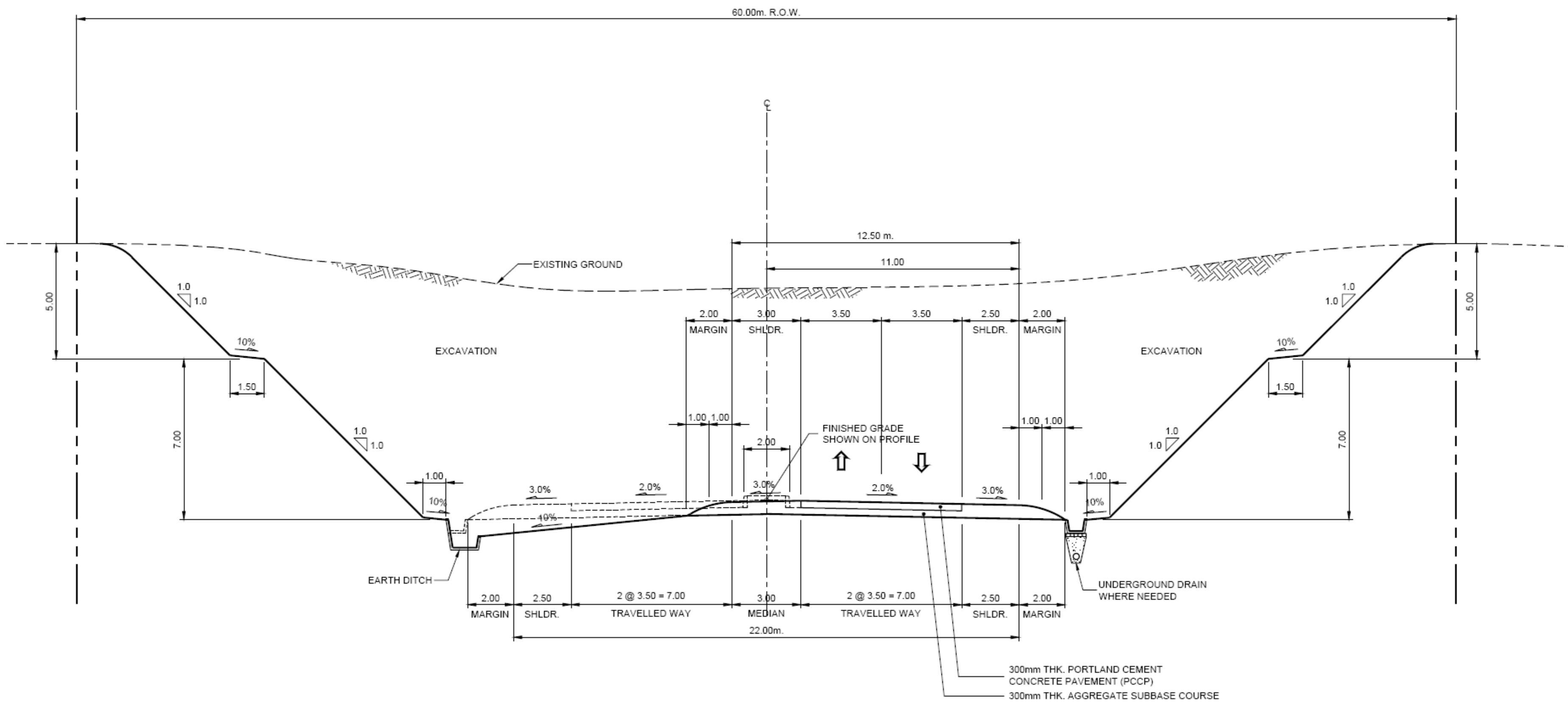


FIGURE 10.2-1 (1) TYPECAL ROADWAY CROSS SECTION CUT (1)



TYPICAL ROADWAY SECTION (Cut Height = 7~12m.)
Cut (2)

Scale 1:200

FIGURE 10.2-1 (2) TYPECAL ROADWAY CROSS SECTION CUT (2)

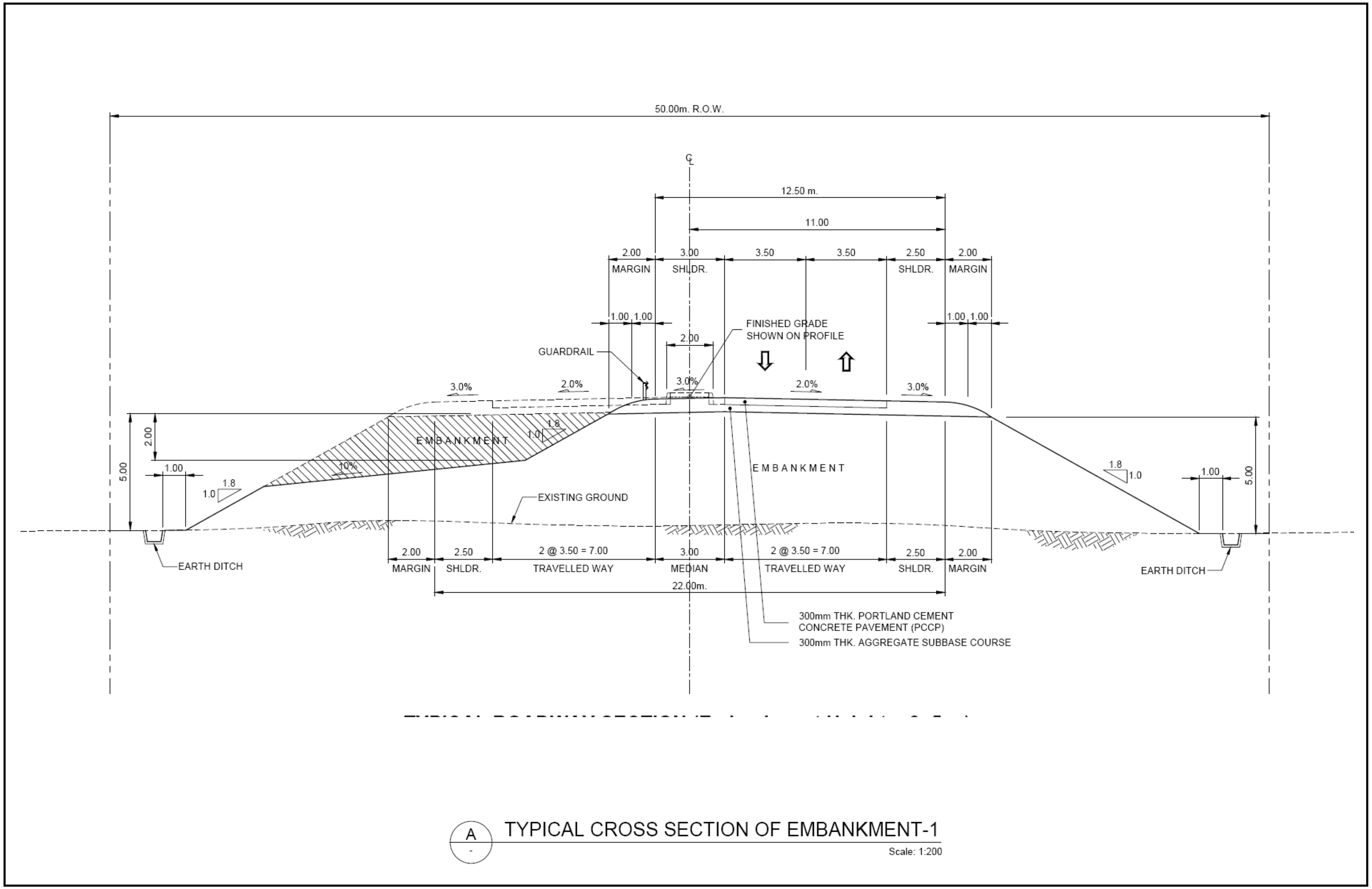


FIGURE 10.2-1 (3) TYPECAL ROADWAY CROSS SECTION EMBANKMENT-1

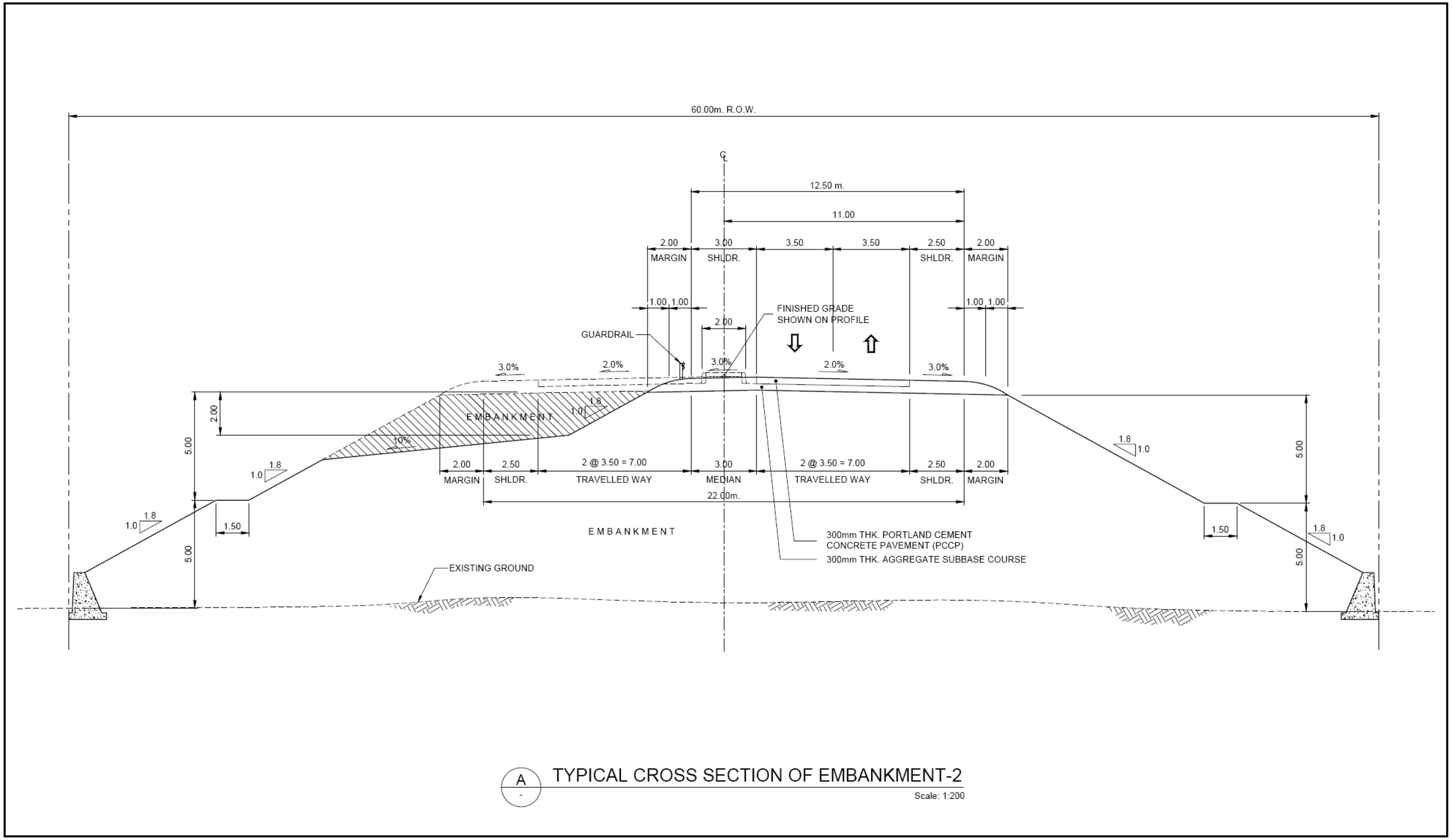


FIGURE 10.2-1 (4) TYPECAL ROADWAY CROSS SECTION EMBANKMENT-2

10.2.3 Tunnel Design Standards

(1) Tunnel Design Standard And Criteria

The following design standards are to be applied to the design for Davao Bypass Tunnel;

1) Basic Geometric Design Standard for Tunnel

The basic geometric design standards for two lane carriageway tunnel to be adopted are the following;

- Design Speed : 60 km/hr
- Carriageway width :3.5m
- Shoulder : 1.50m
- Maximum super elevation of Carriageway: 5.00 %
- Cross fall of Carriageway: 2.00 %
- Vertical clearance : 5.00m
- Alternatively, the following standards will also be adopted as the Design Standards
- Design Guidelines Criteria and Standards. For Public Works and Highways. Department of Public Works and Highways. Volume 3, Part 3-Highway Design.
- Road Safety Manual 2003 – PIAC Technical Committee on Road Safety
- (Permanent International Association of Road Congresses Publications)
- Japan Standard for Mountain Tunneling. Japan Society of Civil Engineers.

(2) Tunnel Cross Section

Figure 10.2-2 shows the typical tunnel cross section for Davao Bypass Project adopted based on the above standard and criteria and Tunnel cross section is likewise shown.

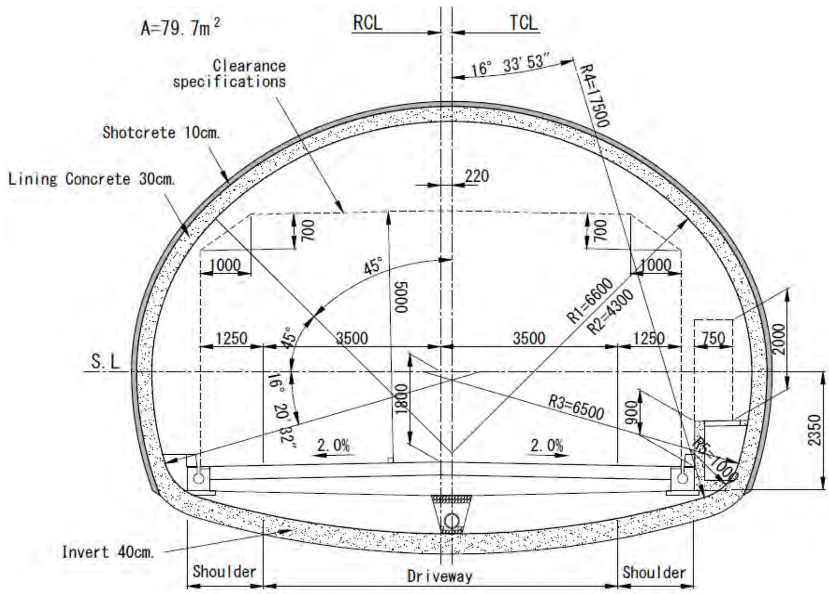


FIGURE 10.2-2 PROPOSED DAVAO CITY BYPASS TUNNEL CROSS SECTION

Photo 10.2-1 shows a sample of a two-lane Japanese tunnel, which was installed with a plastic (flexible) poles to minimize a head-on collision.

PHOTO 10.2-1 TWO-LANE TUNNEL IN JAPAN

10.2.4 Structural Design Standards

(1) Code and Specifications

The Structural Design Standards shall be in accordance with the following codes and guidelines:

- Design Guidelines Criteria and Standards for Public Works and Highways,
- L. O. I. 112, dated August 8, 1973, concerning gross weights of freight trucks and other vehicles.
- P. D. 187 as amended by P. D. 748 and Batas Pambansa Blg. 8. An act of defining the Metric System and its units, providing of its implementation and for other purposes and MPWH Memorandum Circular No. 6 dated January e, 1983, re: Metric System (SI) Tables.
- Standard Specifications for Highways and Bridges, Revised 1995 or latest edition.
- Standard Specifications for Highway Bridges, adopted by the American Association of State Highway and Transportation Officials (AASHTO), 1977 or latest edition.
- Prestressed Concrete Institute (PCI) Design Handbook (Latest Edition).
- Manual of the American Institute of Steel Construction (AISC), 8th or latest edition
- Standard Specifications of American Society for Testing and Materials Joint Circular among Department of Public Works and Highways,

(2) Loadings Specifications

1) General

Structures shall be proportioned with the existence of the following loads and forces:

a) Dead load
b) Live load
c) Impact or dynamic effect of the live load
d) Sidewalk live load
e) Seismic load
f) Wind load
g) Thermal forces
h) Earth pressure

2) Dead Load

The dead load shall consist of the weight of the complete structure, including the roadway, sidewalks, car tracks, pipes, conduits, cables and other public utility services.

The following unit weights shall be used in computing the dead load:

No.	Items	Unit Weight (kN/m^3)
1	Steel or Cast steel	77
2	Cast Iron	71
3	Aluminum alloys	27.5
4	Timber (treated or untreated)	8
5	Concrete, plain or reinforced	24
6	Compacted sand, earth and gravel or ballast	19
7	Loose sand, earth and gravel	16
8	Macadam or gravel, rolled	22
9	Cinder filling	10
10	Pavement, other than wood block	24
11	Railway rails, guard rails, and Fastenings (per linear meter of track)	31
12	Asphalt plank, 25.0mm thick	430Pa
13	Stone Masonry	26

3) Live load

MS18 (HS-20-44)

4) Impact load

I = 15.24/(L+38)
Where

I: Impact fraction (maximum 30%)
L: Length in m of the portion of the span which is loaded to produce the maximum stress in the member.

5) Sidewalk Live load

Span 0 to 7.62m P=4070Pa
Span 7.925m to 30.480m P=2873Pa
Span 30.480m over P = (1435+43800/L) x (16.7-w) / 15.2
Where

P: live load per m2 (Pa), Max 2873Pa
L: Loaded length of sidewalk in m
W: Width of sidewalk in m

6) **Seismic load**

A= 0.4
SPC: D
Where

A: Acceleration Coefficient
SPC: Seismic Performance Category (A>0.4, Essential Bridges IC = I then SPC D)

(3) **Materials and Design Stresses**

All materials to be used in the project shall conform to the DPWH Standard Specifications (2004), and AASHTO Code.

1) **Concrete**

Description	fc' (min.) MPa	Maximum Side of Concrete Aggregates (mm)	Minimum Concrete Cover (mm)
a. Superstructure			
- Deck slabs	28	20	Deck slab with BWS Top:50 Bottom:25 Others:35
- Sidewalk, railings, parapet, medians	21	20	
- PSC I-girders	38	20	PSC I-girders:35
b. Substructure			
- PC pier copings, columns, footings	28	20	Pier Copings, RC & PSC: 50 PSC Hammerheads: 40
- PSC Pier copings, rotating pier head	38	20	RC columns: 50 Footing and Bored Piles: 75
- RC Abutment walls, footings	28	20	Abutment Walls: 50
- Bored piles	28	20	
c. Earth covered RC Box structures	28	20	Earth covered Box structures: 50
d. Other concrete (normal use)	21	20	
e. Lean concrete (for leveling)	17	25	
f. Non Shrink grout	41	40	

2) **Reinforcement Steel**

Reinforcing steel shall conform to AASHTO M31 (ASTM A515) GRADE 40, Deformed with minimum yield strength fy =278MPa

3) **Prestressing**

All Prestressing steel shall be high strength stress relieved wires or strands with an ultimate stress, fs' = 1860 MPa
Prestressing steel shall be free from kinks, notches and other imperfections that will tend to weaken its strength or its bonding properties with concrete.

4) **Structural Steel**

All structural steel shall conform to the requirements of AASHTO or ASTM Designations as follows;
Steel plates and rolled shapes: AASHTO M183 (ASTM A36)
Bolts: AASHTO M164 (ASTM A325)
Welds: AWS D1.1 – 183, E70XX series

10.2.5 Pavement Design Standards

The pavement design is in accordance with the "Guide for Design of Pavement Structures, 1993" by the American Association of the State Highway and Transportation Officials and in reference also to "Design Guidelines, Criteria and Standards for Public Works and Highways" by the Department of Public Works and Highways.

10.2.6 Drainage Design Standards

(1) General

The hydrological study is developed based on the project area's meteorological/hydraulic data, topographical / hydrological surveys carried out in this project. The catchment area of rivers or channels at the bypass road crossing is measured using of 1:50,000 scale topographical map published by NAMRIA. The cross sections and riverbed profiles of the rivers at bypass road crossing are obtained by project topographical survey.

Hydrological surveys about following items are conducted for calculating the numerical value, etc. necessary to hydrological and hydraulic studies.

TABLE 10.2-3 SURVEY ITEMS FOR HYDROLOGICAL SURVEYS

Items		Institutions Concerned	Remarks
Meteorological Survey	General Weather Conditions (Temperature, Relative Humidity, Wind Speed and Direction, Evapo-transpiration, Sunshine Hours, Station Information, etc.)	PAGASA	
	Rainfall (Annual / Monthly / Daily rainfall, Rainfall Intensity Curve, etc.)	PAGASA	
Hydrological Survey	Annual Maximum Discharge (Peak), Annual / Monthly / Daily Discharge, Annual Maximum High water level, Station Information, etc.	BRS of DPWH	
Bibliographic Survey	Related Design Criteria / Standards / Study Reports, Topographic Maps, etc.	DPWH, Davao City, NAMRIA, JICA, etc.	
Interview Survey	Flood Situation Surrounding Related Bridge Sites	(Local Residents)	

Source: JICA Study Team

(2) Hydraulic Design Criteria

1) Design Criteria and Standards

In general, design criteria and standards concerning hydrology and hydraulics in Philippine, are referred to the following documents:

- DPWH Design Guidelines, Criteria and Standards for Public Works and Highways published in 1980.
- FHWA (Federal Highway Administration, USA), HEC (Hydraulic Engineering Circular) series
- U.S. Army Corps of Engineers, Hydrologic Engineering Center, HEC-HMS, HEC-RAS and HY-8 Manuals and Technical References.

These standards will be proposed hydrologic and hydraulic design criteria which are appropriate for project requirements. Also, these standards will cover the following items:

- Hydrologic Design
- Design Frequency or Return Period

- Runoff Computation Methods, Runoff Coefficients
- Rainfall Intensity
- Level of Development in the Watersheds
- Hydraulic Design
- Manning's Roughness Coefficient
- Expansion and Contraction Loss Coefficients
- Freeboard

Drainage design criteria of this study are shown in **Table 10.2-4**.

TABLE 10.2-4 DRAINAGE DESIGN CRITERIA OF THIS STUDY

Items of Criteria		Criteria	Applied Standards	Remarks
Hydrologic design		Based on the data from PAGASA	Various documents including DPWH standards	
Design frequency or return period	Rivers (Bridges)	50-year flood with sufficient freeboard to contain the 100-year flood	DPWH standards	
		25-year flood with sufficient freeboard to contain the 50-year flood	DPWH standards	
	Culverts (Box)	25-year flood with sufficient freeboard to contain the 50-year flood	DPWH standards	
	Culverts (Pipe) Esteros/Creeks Drainage pipes	15-year flood with sufficient freeboard to contain the 25-year flood	DPWH standards	
	Embankments	10-year flood	DPWH standards	
	Ditches and road surface	2-year flood	DPWH standards	
Runoff computation methods, runoff coefficients	Computation methods for waterways with catchment area of 20 km2 or more (Davao, Lasang, Talomo, Lipadas, Matina Rivers)	Specific discharge, by drainage area rate from probable hydrological value (flood frequency analysis) and unit hydrograph method	by calculations	
	Computation methods for other waterways, channels with catchment area less than 20 km2	Rational Formula	DPWH standards, HEC	
	Runoff coefficients	**Table 10.2-5**	DPWH standards, HEC	
Rainfall intensity-duration-frequency		Based on the data from PAGASA	by calculation	
Level of development in the watersheds		Based on the data from land use plan of Davao city	-	
Hydraulic design	Hydraulic computation method (Bridges)	Based on the calculation by HEC-RAS	HEC	
	Hydraulic computation method (Culverts)	Based on the calculation by Rational Formula and confirmed/checked with HY-8 Software	HEC	
	Minimum size of drainage pipes	910 mm	DPWH standards	

Items of Criteria	Criteria	Applied Standards	Remarks
Manning's roughness coefficient	**Table 10.2-6**	DPWH standards, HEC	
Expansion and contraction loss coefficients	(Various values)	HEC	
Freeboards	Bridge: 1m minimum freeboard with no debris and 1.5m minimum free board for waterways with debris load. Culverts: avoid to 2 barrel installations in debris prone areas	DPWH standards	

Source: JICA Study Team

TABLE 10.2-5 RUNOFF COEFFICIENT C

Watershed Cover or Type of Surface	Run-off Coefficient, C
Concrete or asphalt pavement	0.80 – 0.90
Steep grassed areas (2:1)	0.50 – 0.70
Flat residential with about 30% of area impervious	0.40
Flat residential with about 60% of area impervious	0.60
Moderate steep residential with 50% of area impervious	0.65
Moderate steep residential with 70% of area impervious	0.80
Flat commercial with about 90% of area impervious	0.80

TABLE 10.2-6 VALUES OF MANNING'S ROUGHNESS COEFFICIENT "N"

Glass, plastic, mechanical metal	0.010	
Dressed timber, joints flush	0.011	
Sawn timber, joints uneven	0.014	
Cement plaster	0.011	
Concrete, steel troweled	0.012	
Concrete, timber forms, unfinished	0.014	
Untreated granite	0.015	- 0.017
Brickwork or dressed masonry	-0.014	
Rubble set in cement	0.017	
Earth, smooth, no weeds	0.020	
Earth, some stones and weeds	0.025	
Natural river channels:		
Clean and straight	0.025	- 0.030
Winding, with pools and shoals	0.033	- 0.040
Very weedy, winding and overgrown	0.015	- 0.300
Clean straight alluvial channels	$0.031d^{1/6}$	
	(d=D-75 size in ft.)	

2) Hydraulic Design Criteria of Bridge

In order to design opening of the bridge waterway, the following design criteria for hydraulics are required.

- The backwater does not significantly increase the flood damage to properties upstream of the bridge.
- The velocity through the bridge does not damage the road facility or increase the damages to downstream properties.

- The existing flow distribution is maintained to the extent practicable.
- The pier and abutment are designed to minimize the flow disruption. (Contraction scour does not occur at proposed bridge site.)
- Potential local scour is within acceptable limits.
- Clearance at the structure is adequately designed to pass safety any anticipated debris. (The elevation of bottom of bridge girder is higher than "Highest high water level + Freeboard or Navigation channel height".)

The design return period, the clearance from the bridge girder to high water level shall be compliant with authorized standards by the organizations concerned. The high water level of related rivers and the estimation of scouring shall be determined based on the HEC standards and HEC-RAS computation.

3) Hydraulic Design Criteria of Culvert

Lateral road drainage is mainly through culverts and bridges. The size of the flood opening is determined by the catchment area parameters and consideration of existing nearby structures.

The hydraulic design requires considering the following points:

- Head loss due to contraction at the entry of the culvert.
- Head loss at the inlet, through the culvert and outlet due to the roughness.
- Tailwater level and downstream condition

The existing topography is taken into consideration in determining the culvert slope in order to minimize excessive excavations at both ends. The type of inlet and outlet is designed according to the site conditions. The culvert cross-section is determined based on the HEC standards and HY-8 computation.

4) Hydraulic Design Criteria of Road Embankment

The embankment which is made of earth and sand material, and bridge super structure is very weak to overtopping and bumping, therefore planner must consider the safety countermeasures such as clearance.

The freeboard as the DPWH standards is applied for the embankment. Protection for the embankment shall be ensured using the suitable protection works. The median size of the loose riprap is determined based on the procedures provided in Design of Riprap Revetment (HEC14).

In order to protect the above mentioned criteria, the high water level (HWL) of the rivers is required. And it will be checked whether the HWL influences the bypass road. All HWL shall be shown in the design drawings.

10.2.7 Slope Design Standards

(1) General

Since the alignment of the proposed bypass road go through the undulating hilly terrain of 50-200m above sea level of 2-8km inland side of the Pan-Philippine Highway, many large-scale cut slopes of 20 meter or more in height are planned in the proposed bypass road.

The unconsolidated soil layers of sand and gravel are widely laying in the section which the cut slopes are planned. Appropriate slope protections of the cut slopes are needed, because the unconsolidated soil layers of sand and gravel will be easily eroded.

The slope protection is intended to protect the slopes by the vegetation or structure for ensuring the stability of the slopes, preserving of the natural environment and landscaping.

On the other hand, the excavated materials of the above-mentioned excavation sections should be used as banking materials of the embankment planned on the valleys, and the excavated materials of the tunnel section planned between the Matina River and Davao River should be also included in the banking materials. Therefore, it is necessary to design the embankment slopes in consideration of the type and characteristics of the excavated materials in the project road section.

In this section, as the cut slope design standards, the contents about Standard Slope Gradients for Cut which is closely related to the slope protection, Cut Slope Protection Types and Purposes, Selection Method of Cut Slope Protection and Considerations for Application of each Cut Slope Protection are mentioned. Also, as the embankment slope design standards, the contents about Standard Slope Gradients for Embankment and Slope Protection of Embankment are mentioned.

(2) Standard Gradient of Cut Slopes

The natural subsoil and rocks are composed of heterogeneous soils (including gravel and boulder) and rocks which the discontinuity (consisting of joints, faults and etc.) and the weathered alteration portion are present.

Because Philippines is a country composed of islands , located on the Circum-Pacific volcanic belt in the same way as Japan, the various geological conditions are very similar to Japan. From this, it is considered that it is appropriate to refer to the standard slope gradient empirically determined which is generally used in Japan when the cut slope gradient is determined.

Therefore, Standard Slope Gradient for Cut which is mentioned in Road earthwork - Guideline for Stability of Cut Slopes and Natural Slopes: June 2009 (issued by Japan Road Association) of Japan is given in the **Table 10.2-7**, as the standard gradient of cut slopes of the project road.

The Standard Slope Gradient for Cut which is shown in **Table 10.2-7** can be applied in a prerequisite condition that the cut slopes may be protected by vegetation and the like, the cut height that can be applied varies by the condition of subsoil and rocks.

When the standard slope gradient in **Table 10.2-7** is applied to the slopes design, the slope gradient of each slope stage should be decided by the condition which the cut height is the height from the bottom of each slope stage to the top of the whole of slope, because the whole slope is divided into the several slope stages by berms.

Besides, in case of the soil slopes, the applicable scope of the standard slope gradient in **Table 10.2-7** is up to the cut height ranging 10-15m. When the cut height is more than the applicable scope, it is necessary the slope gradient is changed at gentle than the standard slope gradient. But, there are many cases which the standard slope gradient is applied if the cut height is within about 20 m (within three slope stages).

TABLE 10.2-7 STANDARD SLOPE GRADIENTS FOR CUT

Condition of Subsoil and Rocks		Height of Cut	Gradient
Hard Rock			0.3:1.0 to 0.8:1.0
Soft Rock			0.5:1.0 to 1.2:1.0
Sand	Not Dense, and Poor Particle Size Distribution		1.5:1.0 or More Gentle
Sandy Soil	Dense	5m or less	0.8:1.0 to 1.0:1.0
		5m to 10m	1.0:1.0 to 1.2:1.0
	Not Dense	5m or less	1.0:1.0 to 1.2:1.0
		5m to 10m	1.2:1.0 to 1.5:1.0
Sandy Soil Mixed with Gravel or Rock Masses	Dense, or Good Particle Size Distribution	10m or less	0.8:1.0 to 1.0:1.0
		10m to 15m	1.0:1.0 to 1.2:1.0
	Not Dense, or Poor Particle Size Distribution	10m or less	1.0:1.0 to 1.2:1.0
		10m to 15m	1.2:1.0 to 1.5:1.0
Cohesive Soil		10m or less	0.8:1.0 to 1.2:1.0
Cohesive Soil Mixed with Rock Masses or Cobblestones		5m or less	1.0:1.0 to 1.2:1.0
		5m to 10m	1.2:1.0 to 1.5:1.0

Source: Road earthwork - Guideline for Stability of Cut Slopes and Natural Slopes : June 2009 (Issued by Japan Road Association)

On the other hand, when the cut height is more than 20 m (within three slope stages), there are problems that the repair and maintenance of the slopes is difficult, due to the several reasons such as the crane cannot reach the slope top. Therefore, on the occasion of deciding the vertical alignment, it is desirable to make an effort the cut height become 20 m or less.

In addition, even if the cut height is more than 20 m (within three slope stages), the standard slope gradient is applicable within the scope of until 10-15 m below the top of whole slope. Therefore the gradient of slope below than 10-15 m from the top should be studied. Alternatively, the case of making the steep slope than the standard slope gradient by the slope structures should be studied. However, because it is common that the condition of subsoil and rocks is as good as the lower part, as a consequence, there are several cases which the whole slope is constructed with the same slope gradient.

(3) Cut Slope Protection Types and Purposes

The strength of the subsoil and rocks is reduced by influences of loosening due to the cut (stress release), weathering, erosion and infiltrating water. Aforementioned standard slope gradient for cut is the experiential stable gradient which is considered the strength reduction of the subsoil and rocks occurring with the progress of time. And the protecting the cut slopes by vegetation and the like is a prerequisite condition for using the standard slope gradient. Therefore, it is necessary to study the slope protection by planting, even if the slope gradient is gentle than the standard gradient. In addition, when the slope gradient is steep than the standard gradient, or in case of a special conditions of subsoil and rocks, it is necessary to consider a high-performance slope protection than planting.

The slope protections can be divided into the planting consisting of sowing and sodding, etc., and the slope structures consisting of mortar/concrete spraying (shotcrete) and grating crib works, etc..

The cases of using the planting and the slope structures individually for slope protection are many. But, there are cases of using the combination of planting and slope structures due to preserving of the natural environment and landscaping at the site of unstable geotechnical conditions.

The main types and purposes of the slope protection are shown in **Table 10.2-8**.

TABLE 10.2-8 MAIN TYPES AND PURPOSES OF CUT SLOPE PROTECTION

Classification	Types	Purposes
Planting	Sowing	The purpose is the erosion prevention for the soil slopes by Planting. This type should be used when the slope gradient is 1.0:1.0 or less (gentle).
	Vegetation Base Material Spraying	The purpose is the erosion prevention for the soil and rock slopes by Planting. This type should be used when the slope gradient is from 0.5:1.0 to 1.0:1.0.
	Vegetation Mat	The purpose is the erosion prevention for the soil and rock slopes by Planting. This type should be used when the slope gradient is 0.8:1.0 or less (gentle).
	Vegetation Sandbag	The purpose is the erosion prevention by Planting for the inside of "Grating Crib Works using Precast Blocks" mainly.
	Sodding	The purpose is the early erosion prevention for the soil slopes by Planting. This type should be used when the slope gradient is 1.0:1.0 or less (gentle).
	Planting of Sapling	The purpose is the landscaping by trees. This type should be used in the soil slopes when the slope gradient is 1.4:1.0 or less (gentle).
Slope Structures	Mortar/Concrete Spraying (Shotcrete)	The purposes are the weathering prevention, the erosion prevention and the prevention of permeation of runoff. This type should be used at the rock slopes.
	Grouted Riprap	The purposes are the weathering prevention, the erosion prevention, the prevention of permeation of runoff and the prevention of slipping of surface soils. This type should be used at the steep soil slopes.
	Concrete Pitching	The purposes are the weathering prevention, the erosion prevention, the prevention of permeation of runoff and the prevention of slipping of rocks. This type should be used at the steep rock slopes
	Grating Crib Works using Precast Blocks	The purpose is the erosion prevention at sandy soil slopes. This type should be used when the slope gradient is 1.0:1.0 or less (gentle).
	Grating Crib Works using Shotcrete	The purposes are the erosion prevention and the prevention of slipping of surface soils or rocks. This type should be used at soil and rock slopes.
	Stone/Rubble-Concrete Masonry	The purposes are the erosion prevention and the prevention of slipping of surface soils or rocks. This type should be used at the underneath of soil and rock slopes.
	Mat Gabion	The purposes are the improvement of drainage and the prevention of slipping of slopes. This type should be used at the underneath of soil slopes where the spring water is present.
	Rock Bolt Type Anchor	The purpose is the prevention of surface failure or slope failure in soil and rock slopes. This type should be used combining with Grating Crib Works and etc.

Classification	Types	Purposes
	Ground Anchor	The purpose is the prevention of slope failure or landslide. This type should be used combining with Grating Crib Works and etc.

(4) Selection Method of Cut Slope Protection

On the occasion of selecting the slope protection, ensuring of slope stability shall first be considered. The conservation and landscaping of the natural environment should also be considered.

The basic policies of the selection of slope protection are as follows;

(a) When the gradient of cut slope is Standard Slope Gradient for Cut which is shown in the **Table 10.2-8** or less (gentle), in principle, the planting that is fit for the soil/rock conditions of the slopes may be selected.

(b) Even if the gradient of cut slope is gentle than Standard Slope Gradient for Cut which is shown in the **Table 10.2-8** or less (gentle), the planting should be combined with the grating crib works using shotcrete when the slipping of the slope is feared. Also, the mortar/concrete spraying (shotcrete) should be selected when the weathering of rock slope is feared.

(c) When the gradient of cut slope is steep than Standard Slope Gradient for Cut which is shown in the **Table 10.2-8**or more (steep), the appropriate slope structures should be selected by the soil/rock conditions of the slopes. The slope structure fitting to soil slopes is the grouted riprap only. The slope structure fitting to rock slopes is the concrete pitching only. Also, the slope structures fitting to both soil and rock slopes are the grating crib works using shotcrete, the stone/block masonry, the rock bolt type anchor and the ground anchor.

(d) The grating crib works using precast blocks, the grating crib works using shotcrete and the mat gabion should be selected in the slopes where the spring water is present. In case of using the grating crib works at slopes where the spring water is present, to be packed riprap at the inside of frames is desirable.

(e) The grating crib works using precast blocks, the grating crib works using shotcrete, the grouted riprap and the stone/block masonry should be selected in the sandy soil slopes where the soils are prone to be eroded.

(f) The selection flowchart of the slope protection based on the above-mentioned policies was prepared in the reference of "Road Earthwork - Guideline for Stability of Cut Slopes and Natural Slopes: June 2009 (issued by Japan Road Association) of Japan", is shown in **Figure 10.2-3**.

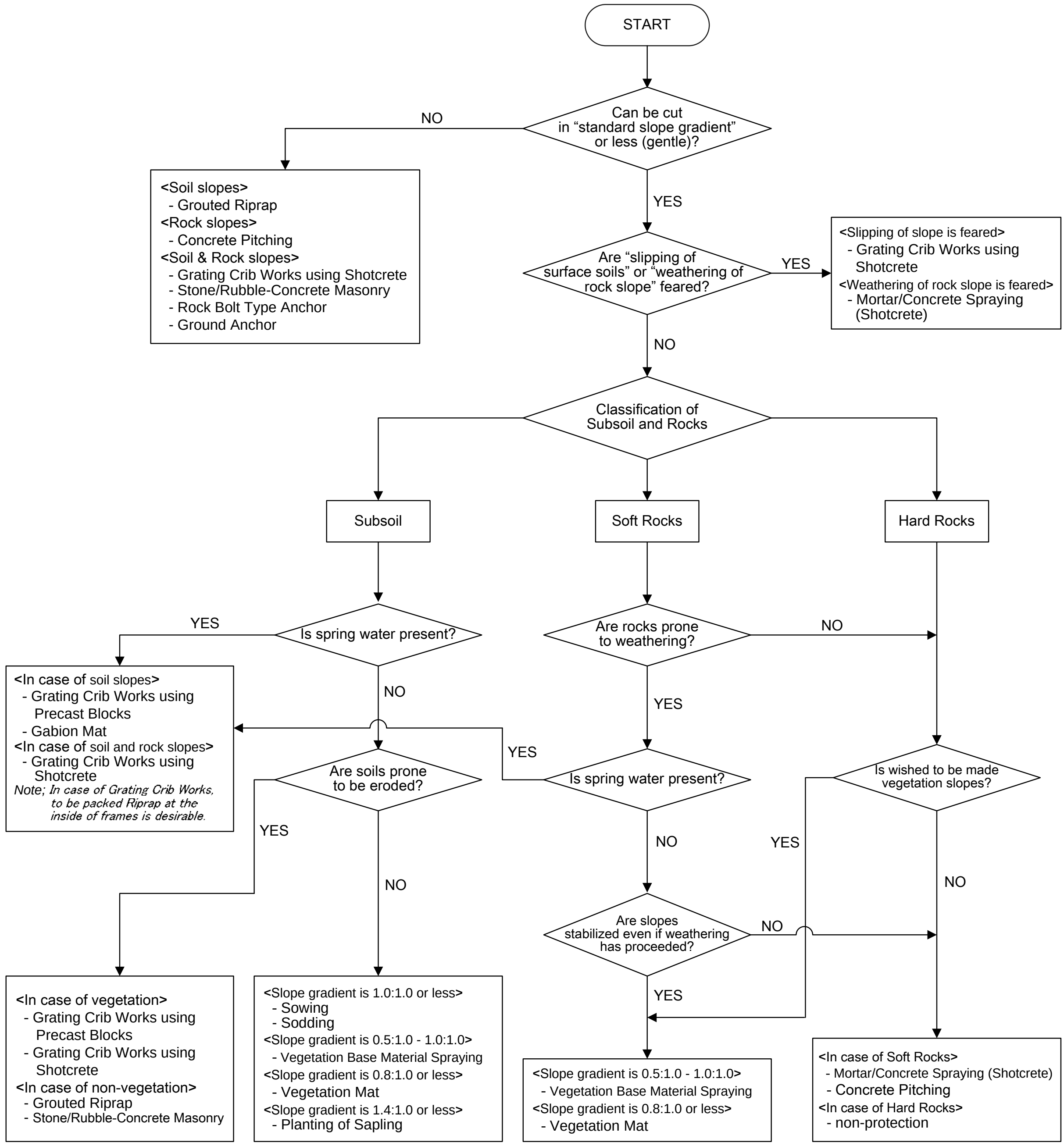


FIGURE 10.2-3 SELECTION FLOWCHART OF CUT SLOPE PROTECTION

(5) Considerations for Application of Each Cut Slope Protection

1) Planting

The optimal weather conditions (temperature, precipitation, etc.) are different; the plant (seed) to be used for the planting should be selected as the proven plant at the neighboring area of construction sites.

In selecting the slope protection type, the applicable conditions (soil type, hardness and gradient) of each protection type described below should be referred.

While in selecting the slope protection type, the applicable conditions (Soil/Rock conditions of the slope, Hardness of the slope, Gradient of the slope) of each protection type described below, should be referred.

(a) Applicable conditions of Sowing

- Soil/Rock conditions of the slope: Cohesive soil, Sandy soil
- Hardness of the ground: Soft (N-value 4-8 or less)
- Gradient of the slope: Gradient of 1.0:1.0 or less (gentle)

PHOTO 10.2-2 WORKING EXAMPLE OF SOWING

(b) Applicable conditions of Vegetation Base Material Spraying

- Soil/Rock conditions of the slope: Cohesive soil, Sandy soil, Gravelly soil, Soft rock
- Hardness of the ground: Hard (N-value 4-8 or more)
- Gradient of the slope: from 0.5:1.0 to 1.0:1.0

Note: - The thickness of the vegetation base material should be changed according with the hardness of the ground. The general range of changing is "1 cm (in case of N-value 4 roughly)" to "10 cm (in case of soft rock)".
- The slopes shall be blanketed by wire mesh for stabilization of the vegetation base material before spraying.

PHOTO 10.2-3 WORKING EXZMPLE OF VEGETATION BASE MATERIAL SPRAYING

(c) Applicable conditions of Vegetation Mat

- Soil/Rock conditions of the slope: Cohesive soil, Sandy soil, Gravelly soil, Soft rock
- Hardness of the ground: Hard (N-value 4-8 or more)
- Gradient of the slope: Gradient of 0.8:1.0 or less (gentle)

Note: - It is necessary to select the optimum product of the vegetation mat according to hardness of the ground.

PHOTO 10.2-4 WORKING EXAMPLE OF VEGETATION MAT

(d) Applicable conditions of Vegetation Sandbag

- Soil/Rock conditions of the slope: Cohesive soil, Sandy soil, Gravelly soil, Soft rock
- Hardness of the ground: Hard (N-value 4-8 or more)
- Gradient of the slope: Gradient of 0.8:1.0 or less (gentle)

Note: - The vegetation sandbag is commonly used as the planting of the inside of grating crib works.

PHOTO 10.2-5 WORKING EXAMPLE OF VEGETATION SANDBAG

(e) Applicable conditions of Sodding

- Soil/Rock conditions of the slope: Cohesive soil, Sandy soil
- Hardness of the ground: Soft (N-value 4-8 or less)
- Gradient of the slope: Gradient of 1.0:1.0 or less (gentle)

Note: - The sodding is commonly used in the narrow slopes that require the slope protection as soon as possible.


PHOTO 10.2-6 WORKING EXAMPLE OF SODDING

(f) Applicable conditions of Planting of Sapling

- Soil/Rock conditions of the slope: Cohesive soil, Sandy soil
- Hardness of the ground: Soft (N-value 4-8 or less)
- Gradient of the slope: Gradient of 1.4:1.0 or less (gentle)

PHOTO 10.2-7 WORKING EXAMPLE OF PLANTING OF SAPLING

2) Slope Structures

The slope structures are commonly used for the prevention of weathering, erosion, permeation of runoff, slipping and surface failure in soil and rock slopes. Also, the slope structures may be used when the reduction of the excavation volume by the slopes of steeper gradient than the standard slope gradient is desired.

When the prevention purposes are against weathering, erosion n and permeation, slipping of surface soils or rocks, the slope structures are generally designed by material, shape and dimensions which have been determined empirically. On the other hand, when the prevention purposes are against slope failure or landslide, the slope structures are generally designed by the stability analysis results which should be carried out based on the geotechnical investigation results.

Considerations for the selection and application of each slope structure are as follows.

(a) Considerations of Mortar/Concrete Spraying (Shotcrete)

- The mortar/concrete spraying (shotcrete) is selected in principle for the prevention purposes against weathering, erosion and permeation of runoff. This type should be used at the rock slopes.
- The spraying thickness should be 8-10 cm, when the slopes are hard rocks with few cracks. Also when the slopes are soft rocks or hard rocks with many cracks it should be 10 cm or more.
- When the spraying thickness is 8-10 cm, the normal spraying material is mortar. Also when the spraying thickness is 10 cm or more, the spraying material is concrete.
- The specified design strength of the sprayed mortar/concrete (shotcrete) shall be 15 MPa or more.
- On the occasion of the spraying of mortar/concrete (shotcrete), the wire mesh, the anchor bar, the anchor pin and the weep hole should be placed on slopes as shown in **Figure 10.2-4**, in principle.

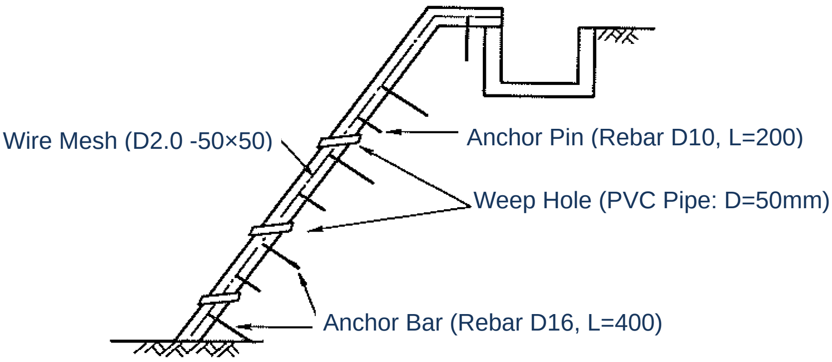


FIGURE 10.2-4 EXAMPLE OF MORTAR/CONCRETE SPRAYING (SHOTCRETE)

PHOTO 10.2-8 WORKING EXAMPLE OF MORTAR/CONCRETE SPRAYING (SHOTCRETE)

(b) Considerations of Grouted Riprap

- The grouted riprap is selected in principle for the prevention of weathering, erosion, permeation of runoff and slipping of surface soils. This type should be used at the steep soil slopes.
- The slope gradient of 1.0:1.0 or less (gentle) is desirable as the slope gradient of construction site.
- The standard thickness of the grouted riprap is approximately 25-35 cm. And it should be decided according to the slope gradient (it should be as thick as the slope gradient is steep).
- The stones of the grouted riprap shall be bedded by the horizontal and vertical grout of mortar, the thickness is 20 mm or more as shown in **Figure 10.2-5**.
- As shown in **Figure 10.2-6**, the finishing mortar shall be applied from slope surface top, so that the exposed face of vertical and horizontal is finished in a straight line. Also the weep hole (PVC pipe) should be placed in the grouted riprap.

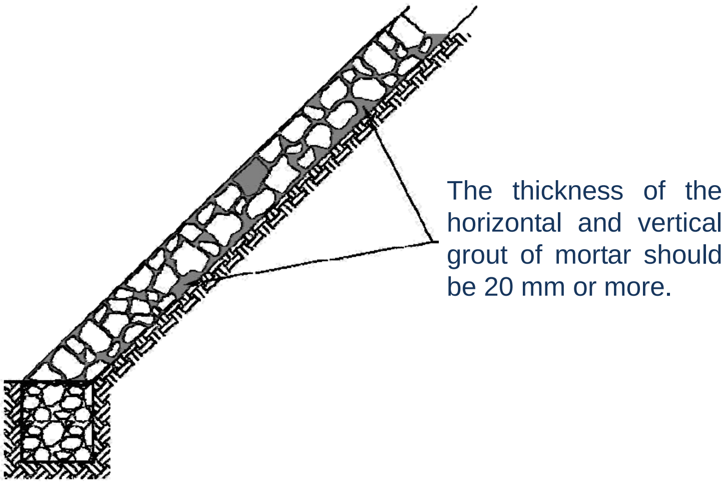


FIGURE 10.2-5 EXAMPLE OF GROUTED RIPRAP (1/2)

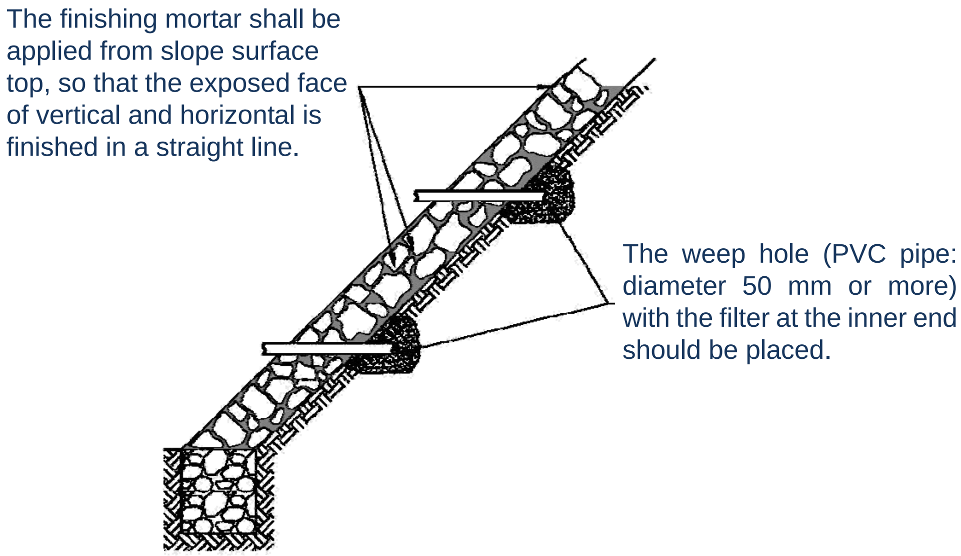


FIGURE 10.2-6 EXAMPLE OF GROUTED RIPRAP (2/2)

PHOTO 10.2-9 WORKING EXAMPLE OF GROUTED RIPRAP

(c) Considerations of Concrete Pitching

- The concrete pitching is selected in principle for the prevention against weathering, erosion, permeation of runoff and slipping of rocks. This type should be used at the steep rock slopes.
- The standard thickness of the concrete pitching is approximately 20-80 cm. And it should be decided according as the slope gradient. The thickness is generally about 20 cm in case of slope gradient 1.0:1.0, and about 60 cm in case of slope gradient 0.5:1.0.
- On the occasion of the construction of the concrete pitching, the H-section steel, the equal-angle steel, the non-slip anchor and the weep hole should be placed on slopes as shown in **Figure 10.2-7**, in principle.

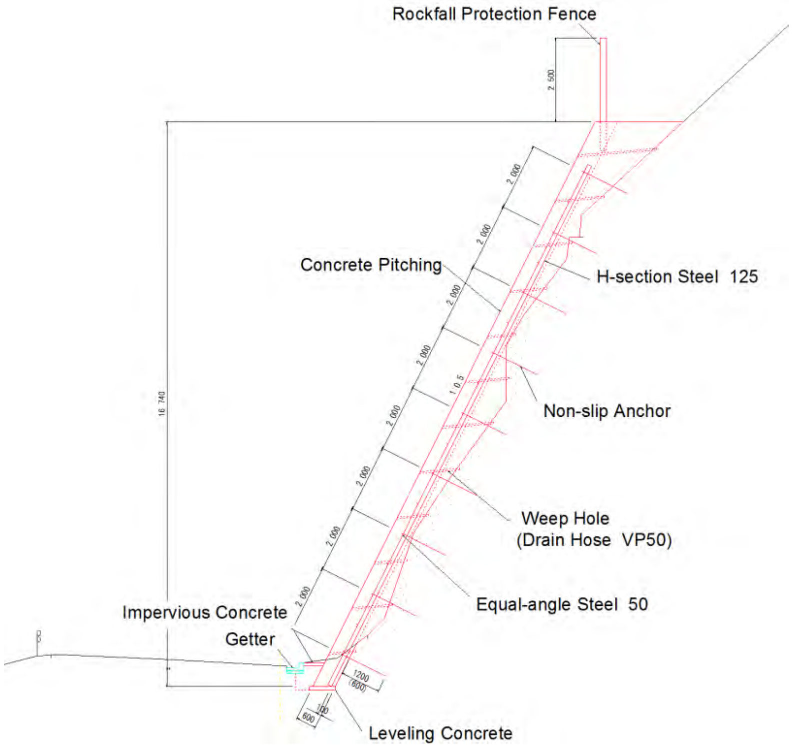


FIGURE 10.2-7 EXAMPLE OF CONCRETE PITCHING

PHOTO 10.2-10 WORKING EXAMPLE OF CONCRETE PITCHING

(d) Considerations of Grating Crib Works using Precast Blocks

- The grating crib works using precast blocks is selected in principle for the purpose of erosion prevention at sandy soil slopes. This type should be used when the slope gradient is 1.0:1.0 or less (gentle).
- Although the vegetation sandbag is commonly packed at the inside of frames of the grating crib works using precast blocks, it is desirable to packed the riprap when the spring water is present.
- On the occasion of the construction of the grating crib works using precast blocks, the anchor bar of 50-100 cm length should be placed at the intersection of frames as shown in **Figure 10.2-8**, in principle.

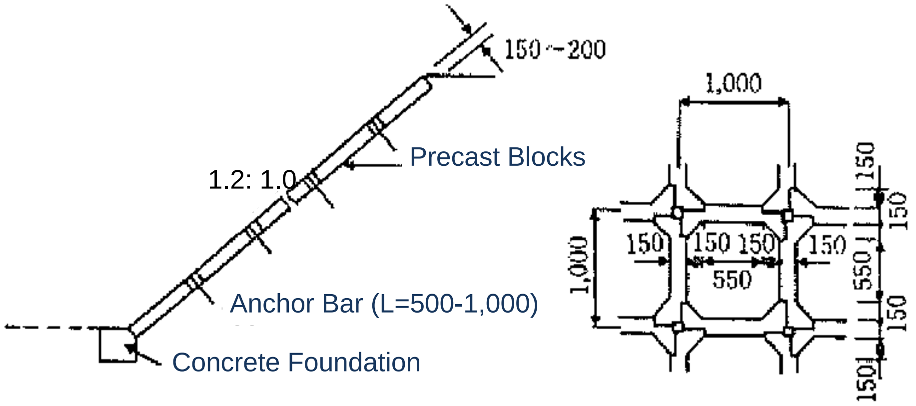


FIGURE 10.2-8 EXAMPLE OF CRATING CRIB WORKS USING PRECAST BLOCKS

PHOTO 10.2-11 WORKING EXAMPLE OF GRATING CRIB WORKS USING PRECAST BLOCKS

(e) Considerations of Grating Crib Works using Shotcrete

- Although the grating crib works using shotcrete should be generally selected for the prevention purposes against erosion and slipping of surface soils or rocks, there are cases of utilization as the part for connecting the heads of the rock bolt type anchor or the ground anchor.
- The grating crib works using shotcrete is the generic name of the grating crib works of reinforced concrete using shotcrete. It is necessary to select the optimum type according to the slope gradient and the purpose of use, because there are several types which consist of the various shapes and sizes of the frame and the frame intervals as shown in **Figure 10.2-9**.
- On the occasion of the construction of shotcrete, the formworks which are made with the welded wire fabric, etc. and the rebar should be placed on slopes in advance.
- The specified design strength of the shotcrete shall be 18 MPa or more.
- Although the vegetation sandbag or the vegetation base material spraying is commonly constructed at the inside of frames of the grating crib works using shotcrete, it is desirable to pack the riprap when the spring water is present.

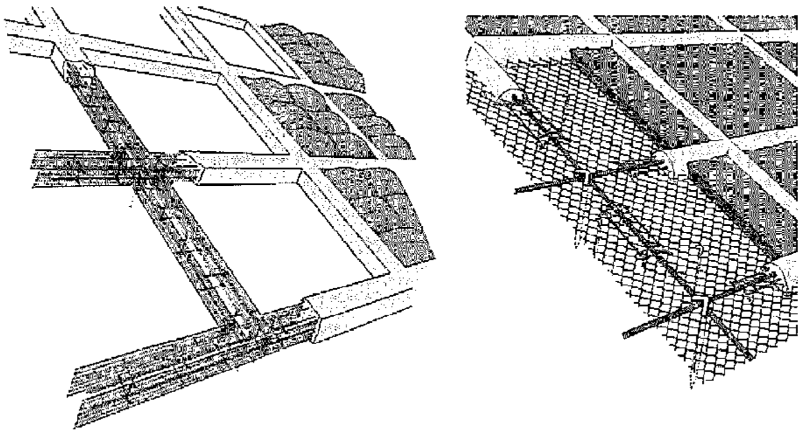


FIGURE 10.2-9 EXAMPLE OF GRATING CRIB WORKS USING SHOTCRETE

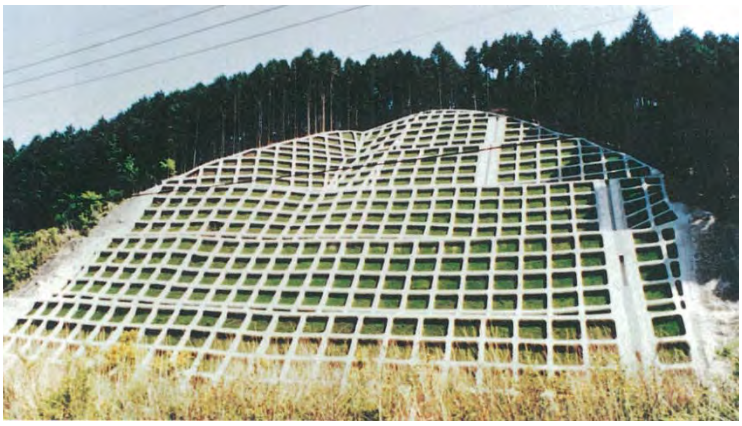


PHOTO 10.2-12 WORKING EXAMPLE OF GRATING CRIB WORKS USING SHOTCRETE

(f) Considerations of Stone/Rubble-Concrete Masonry

- The stone/rubble-concrete masonry is selected in principle for the prevention purposes against erosion and slipping of surface soils or rocks. This type should be used at the underneath of soil and rock slopes.
- Although as this type structure, the stone masonry is commonly used, there is the case of replacing with the rubble-concrete masonry on the consideration of economic efficiency.
- The stone/rubble-concrete masonry should be constructed until the required height or dimensions by the use of the 1:2 mortars (cement 1: sand 2). And like the grouted riprap, the weep hole (PVC pipe) should be placed in the stone/rubble-concrete masonry.
- The standard thickness of the stone/rubble-concrete masonry is approximately 45-75 cm. And it should be decided according to the conditions of shown in **Figure 10.2-10** in case of the soil slopes. In case of the rock slopes, it may be 45 cm or more without regard to the slope height; however the slope height is desirable to be 7 m or less.

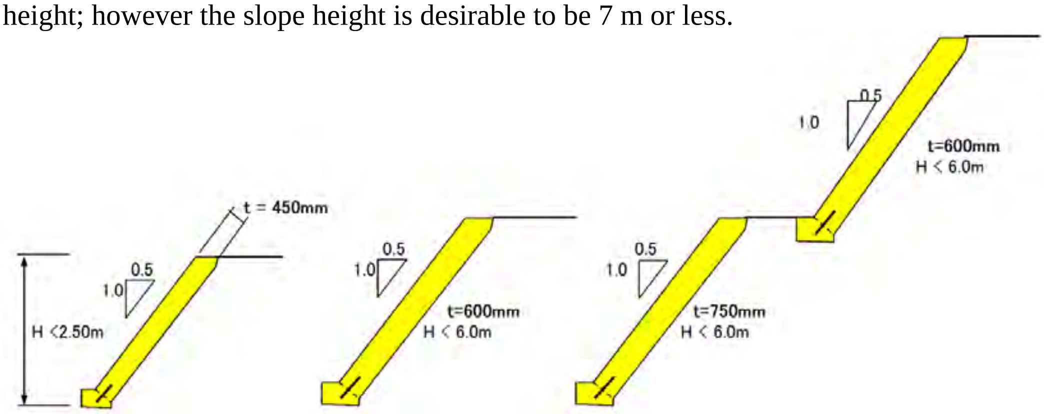


FIGURE 10.2-10 USE CONDITION OF STONE/RUBBLE-CONCRETE MASONRY

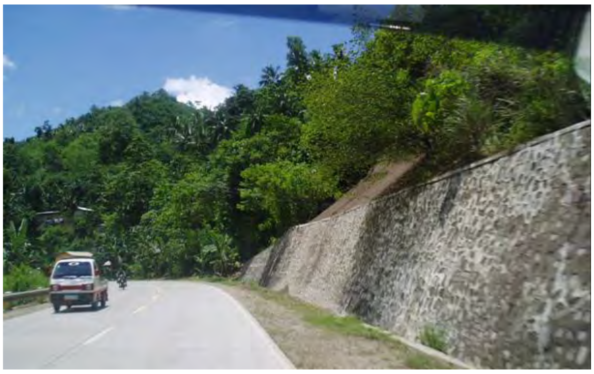


PHOTO 10.2-13 WORKING EXAMPLE OF STONE/RUBBLE-CONCRETE MASONRY

(g) Considerations of Mat Gabion

- The mat gabion is selected in principle for the purposes of the improvement of drainage and the prevention of slipping of slopes. This type should be used at the underneath of soil slopes where the spring water is present.
- The mat gabion is the structure that the riprap/rubble is packed in the basket of rectangular parallel piped which is made with the wire mesh.
- The filter cloth should be placed back of the mat gabion as shown in **Figure 10.2-11** when the outflow of soils by suction due to the spring water is concerned.

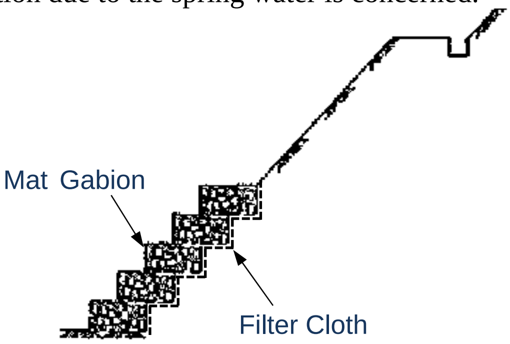


FIGURE 10.2-11 EXAMPLE OF MAT GABION

PHOTO 10.2-14 WORKING EXAMPLE OF MAT GABION

(h) Considerations of Rock Bolt Type Anchor

- The rock bolt type anchor is selected in principle for the purposes of the prevention of surface failure or slope failure in soil and rock slopes.
- The rock bolt type anchor is the method that reinforces the slopes by insertion of the rebars and cement milk into the hole drilled by boring machine. And this method is used frequently when the reduction of the excavation volume by the slopes of steeper gradient than the standard slope gradient is desired.
- The rock bolt type anchor should be designed by the slope stability analysis results which are

carried out based on the geotechnical investigation results in principle.

- The rock bolt type anchor should be used combining with the grating crib works using shotcrete and etc. as shown in **Figure 10.2-12**.

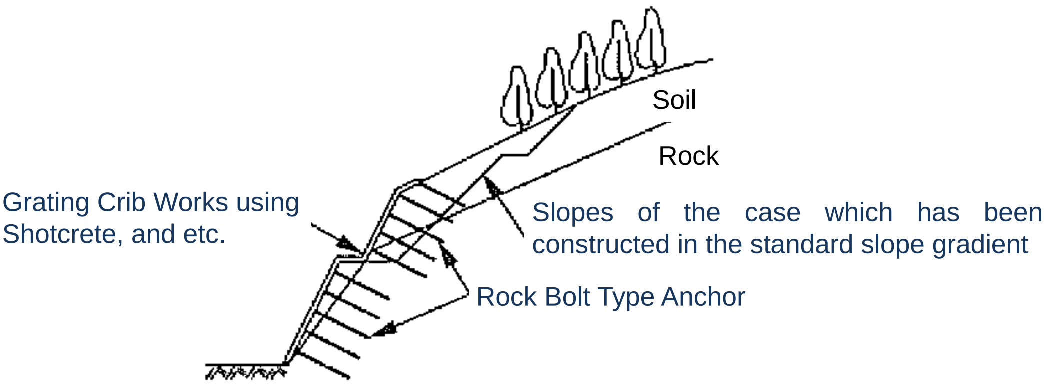


FIGURE 10.2-12 EXAMPLE OF ROCK BOLT TYPE ANCHOR

PHOTO 10.2-15 WORKING EXAMPLE OF ROCK BOLT TYPE ANCHOR (WITH GRATING CRIB WORKS USING SHOTCRETE)

(i) Considerations of Ground Anchor

- The ground anchor is selected in principle for the prevention purposes against slope failure or landslide. This type should be used combining with the grating crib works and etc.
- The ground anchor is the method to hold down the slopes by the pre-stress of the anchor tendon (pre-stressing steel wire) consisting of the tendon and the anchorage, which should be inserted into the hole drilled by boring machine with the cement milk.
- The ground anchor should be designed by the stability analysis results of landslide, etc. which are carried out based on the geotechnical investigation results.
- The ground anchor shall be used combining with the grating crib works using shotcrete and etc. as shown in **Figure 10.2-13**.

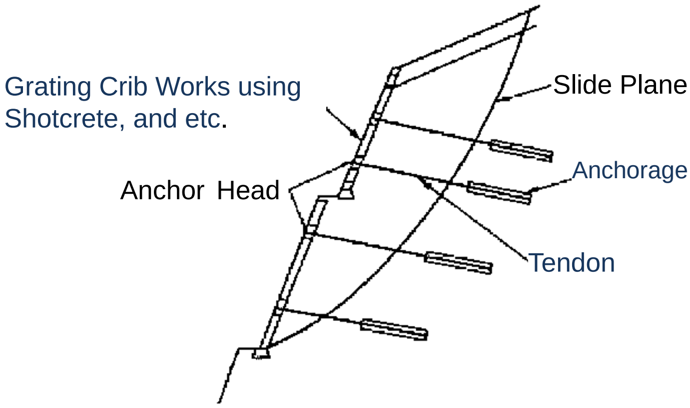


FIGURE 10.2-13 EXAMPLE OF GROUND ANCHOR

PHOTO 10.2-16 CONSTRUCTION STATUS OF GROUND ANCHOR

PHOTO 10.2-17 WORKING EXAMPLE OF GROUND ANCHOR (WITH GRATING CRIB WORKS USING SHOTCRETE)

(6) Standard Slope Gradients for Embankment

Standard Slope Gradient for Embankment which is mentioned in Road Earthwork - Guideline for Embankment: April 2010 (issued by Japan Road Association) of Japan is given in the **Table 10.2-9**, as the standard gradient of embankment slopes of the project road.

The standard slope gradient of embankment slopes is as shown in **Table 10.2-9**, and the height of embankment that can be applied varies by banking materials.

The height of embankment in **Table 10.2-9** is the height difference between top and toe of the embankment slope. Therefore the same slope gradient should be applied at top-toe of the slope without regard to the existence of berms.

TABLE 10.2-9 STANDARD SLOPE GRADIENTS FOR EMBANKMENT WHICH ARE DEPENDED ON BANKING MATERIALS/HEIGHT OF EMBANKMENT

Banking Materials	Height of Embankment	Gradient	Remark
Well-graded sand (SW), Gravel (GW, GP), Silty gravel (GM), Clayey gravel (GC)	5m or less	1.5:1.0 to 1.8:1.0	The standard slope gradient of embankment slopes can be applied in case of some conditions. The conditions are the enough bearing capacity of foundation ground, the no-influence place of the inundation, the well-compacted embankment. The characters in parentheses of "Banking Materials" are the group symbols of the unified soil classification of ASTM (D 2487). The stability analysis of the embankment should be carried out, when the slope gradient is out of range of the standard slope gradients.
	5m to 15m	1.8:1.0 to 2.0:1.0	
Poorly graded sand (SP)	10m or less	1.8:1.0 to 2.0:1.0	
Rock lump (including Rock debris) (GW, GP)	10m or less	1.5:1.0 to 1.8:1.0	
	10m to 20m	1.8:1.0 to 2.0:1.0	
Silty sand (SM), Clayey sand (SC), Lean clay (CL), Silt (ML)	5m or less	1.5:1.0 to 1.8:1.0	
	5m to 10m	1.8:1.0 to 2.0:1.0	
Volcanic cohesive soil (CH, MH)	5m or less	1.8:1.0 to 2.0:1.0	

Source: Road earthwork - Guideline for Embankment: April 2010 (Issued by Japan Road Association): The group symbols were modified based on the unified soil classification of ASTM (D 2487).

Further, the material classification of AASHTO (M57-80), which the materials for embankments and subgrades are targeted, is different from the unified soil classification of ASTM (D 2487) is shown in **Table 10.2-9**, but the rough relationships of the two soil classifications are shown in **Table 10.2.7-4**.

TABLE 10.2-10 ROUGH RELATIONSHIPS BETWEEN UNIFIED SOIL CLASSIFICATION OF ASTM AND MATERIAL CLASSIFICATION OF AASHTO

Banking Materials	Unified Soil Classification of ASTM	Material Classification of AASHTO
Well-graded sand (SW), Gravel (GW, GP), Silty gravel (GM), Clayey gravel (GC)	SW	A-2-4, A-2-5
	GW, GP, GM, GC	A-1
Poorly graded sand (SP)	SP	A-3
Rock lump (including Rock debris) (GW, GP)	GW, GP	A-1
Silty sand (SM), Clayey sand (SC), Lean clay (CL), Silt (ML)	SM, SC	A-2-6, A-2-7
	CL, ML	A-4, A-6
Volcanic cohesive soil (CH, MH)	CH, MH	A-5, A-7

Note: In AASHTO (M57-80), A-1, A-2-4, A-2-5, A-3 are defined as the embankment materials of "excellent to good" quality, and A-2-6, A-2-7, A-4, A-5, A-6, A-7 are defined as the embankment materials of "fair to poor" quality.

(7) Slope Protection of Embankment

The slope protection of embankment should be applied the planting in principle. However, such the slope protection as the grouted riprap should be applied in the inundation risk sites such of the river flood areas.

In addition, when the rock debris is used as banking materials, the slope should be overlaid by the soil blanket on embankment slope (Cohesive soil) for vegetation, as shown in **Figure 10.2-14**, except the case of slope protection of the grouted riprap. The thickness of the soil blanket on embankment slope shall be 30 cm or more in consideration of the growth of vegetation.

The economical sowing is recommended as the planting of embankment slopes, but the stripped sodding (lined turf) is suitable when the slopes are overlaid by the soil blanket on embankment slope.

Further, the structure of the grouted riprap shall be the same structure with the case of the cut slopes (Refer **Figure 10.2-5** and **Figure 10.2-6**).

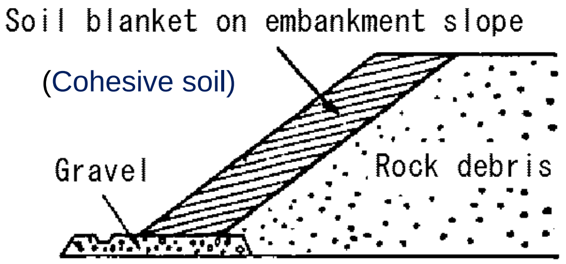


FIGURE 10.2-14 OVERLAYS BY SOIL BLANKET ON EMBANKMENT SLOPE

10.3 ROAD DESIGN

10.3.1 General

Road design concept shows as follows;

- Road design is based on two lanes, considering four lanes widening in the future.
- To minimize the road construction cost and soil disposal impact. The volume of cutting and embankment should be balanced as much as possible.
- To consider not only the accessibility of connecting road and roadside area but also high mobility function as bypass.

10.3.2 Road Cross Section

The centerline of road cross section shows the future four-lane road. Initial stage is to construct the two-lane road at Davao City central side (at seaside) and then the widening stage is to construct additional two lanes at inland side. To minimize the traffic impact during widening road works, demolish and reconstruction of slope protection facilities, it is recommended that cutting and embankment works will be done as four-lane at initial stage. **Figure 10.3-1** shows the typical cross section of embankment and cut at each stage.

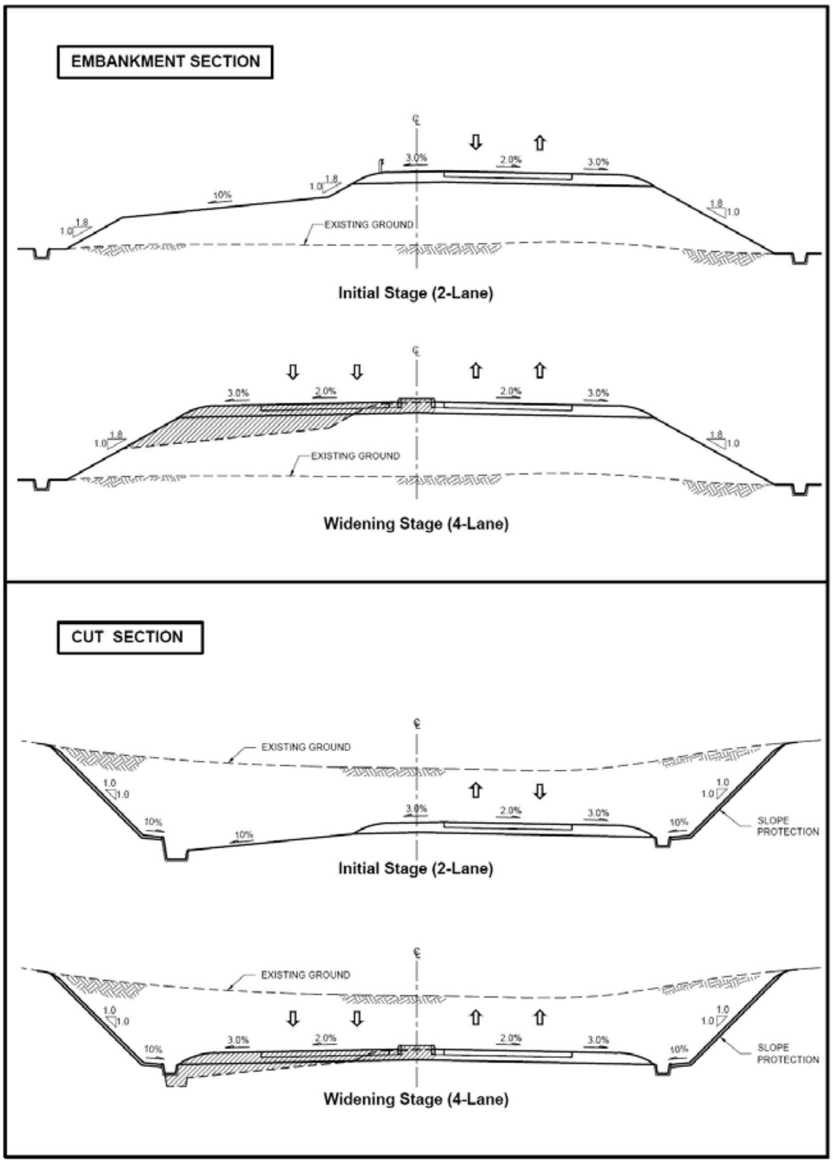


FIGURE 10.3-1 TYPICAL CROSS SECTION (INITIAL AND WIDENING) CONTROL POINT

Major alignment control point was described in Chapter 9 (Alignment Selection of Davao City Bypass).

This section describes the control points for preliminary design based on selected alignment.

- Based on topographical survey result, the preliminary design was conducted to minimize the bridge length, embankment and cut height and to avoid affected structures as much as possible.
- Main changes of horizontal and vertical alignment was done using the above concept.

10.3.3 Embankment and Cut Section

Figure 10.3-2 shows the total length of high embankment and cut section. **Table 10.3-1** shows the total length of high embankment based on the preliminary design.

TABLE 10.3-1 EMBANKMENT AND CUT SECTION LENGTH

Unit: km

	10m > H > 5m	**H > 10m**	**Total**
Cut Section	4.28	6.03	10.31
Embankment Section	3.72	1.55	5.27
Flat (H<5m)	-	-	21.59
Total	8.00	7.58	37.17

Note: Not including bridge and tunnel section

Figure 10.3-2 shows the location map for the high cut and embankment section.

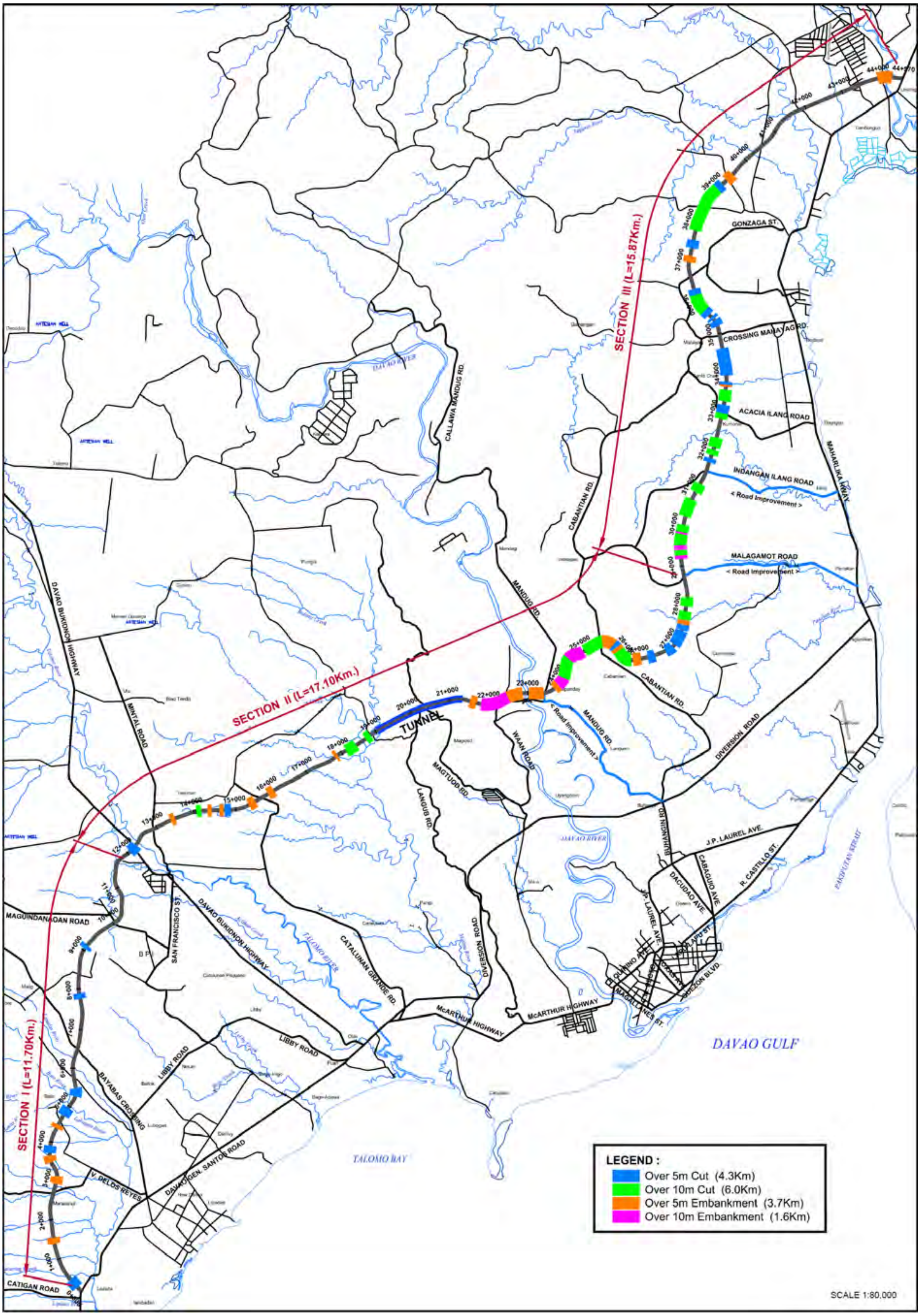


FIGURE 10.3-2 LOCATION MAP OF HIGH CUT AND EMBANKMENT SECTION CROSSING SECTION

(1) Technical Approach

In order to improve the accessibility after the construction of the Bypass, crossing roads are designed.

Technical approach of design is as follows;

1) To provide crossing road to improve accessibility after the bypass construction.
2) To provide flyover at crossing major road underneath to provide high traffic function at the bypass road users.
   - (Beginning Point) Flyover during widening stage (see **Figure 10.3-4**)
   - (End Point) Flyover during widening stage (see **Figure 10.3-5**)
   - Davao-Bukidnon Road Flyover from the initial stage (see **Figure 10.3-6**)

Figure 10.3-3 shows the location map of intersection type. **Figure 10.3-4 ~ Figure 10.3-6** shows three major intersection types considering future widening.

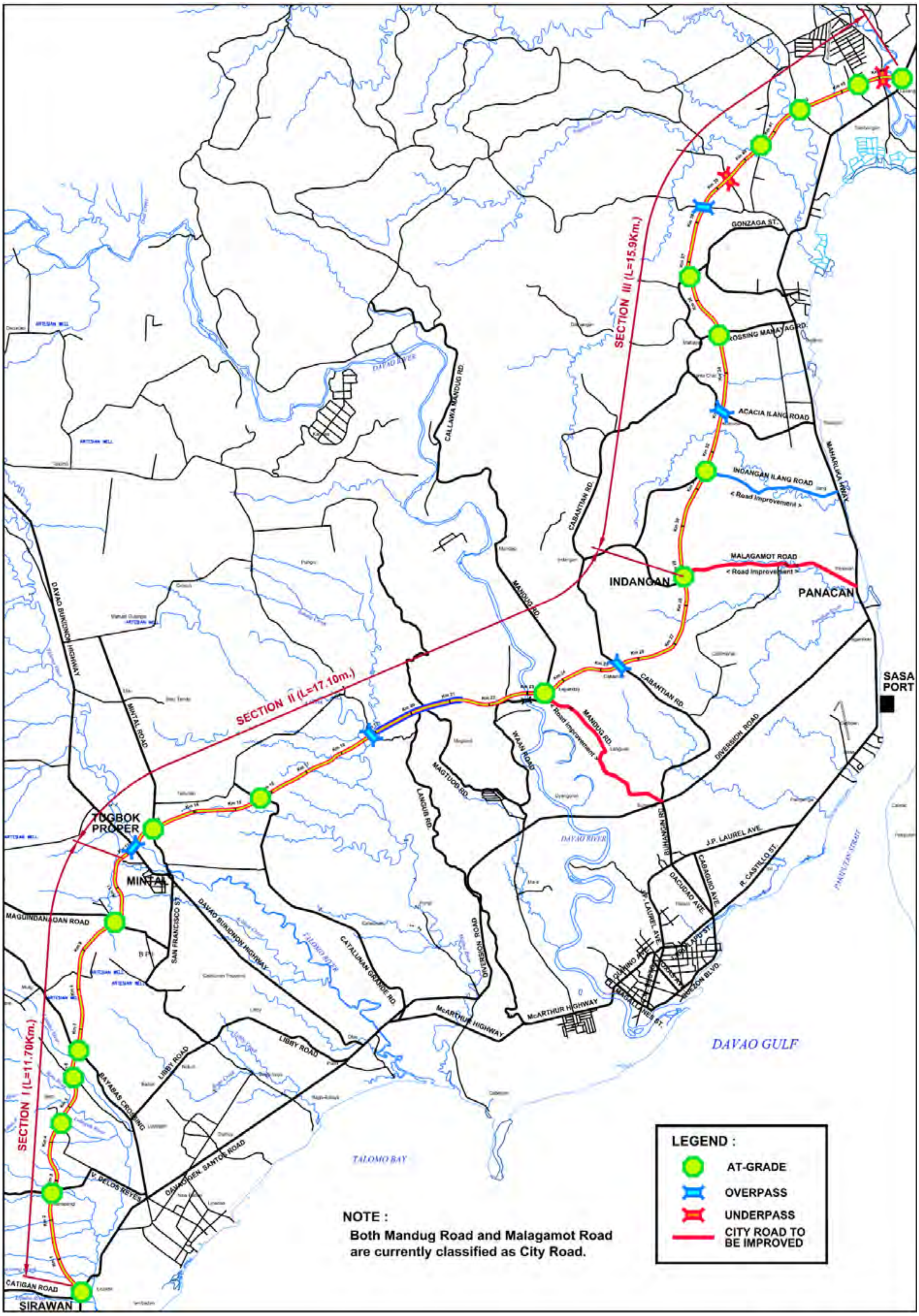


FIGURE 10.3-3 LOCATION MAP OF INTERSECTION TYPE

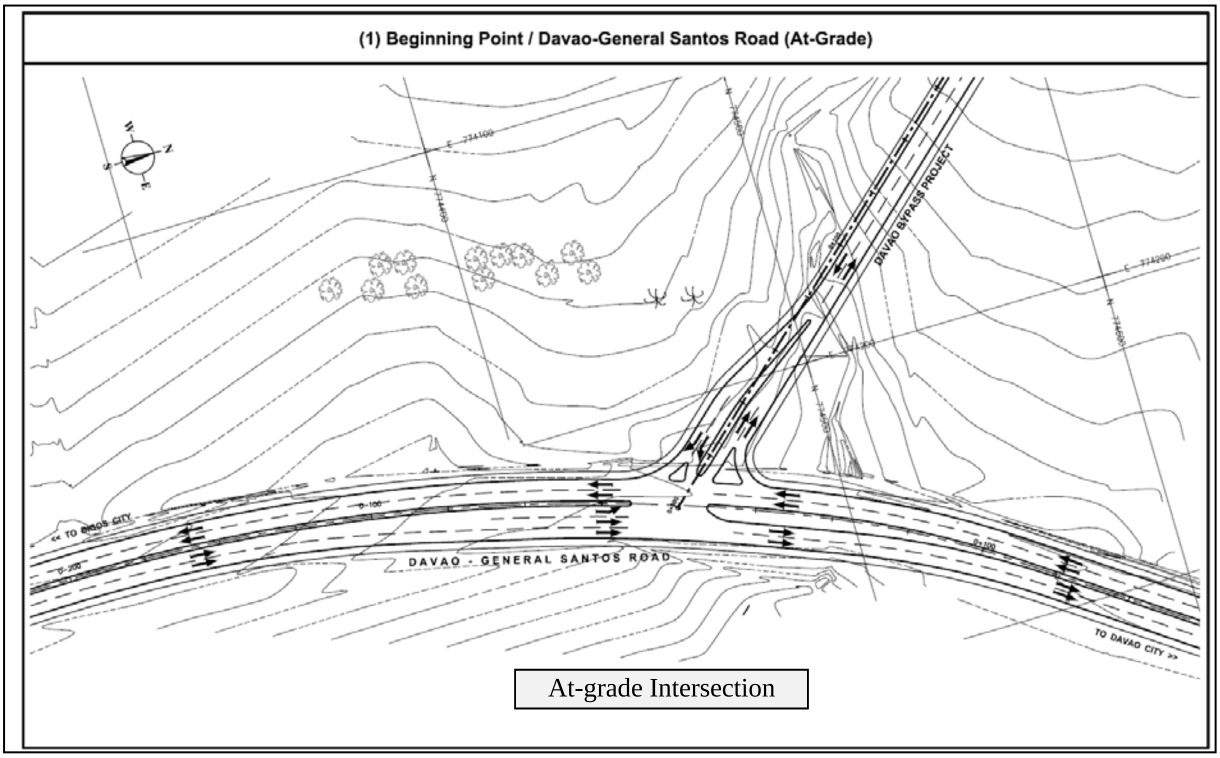


FIGURE 10.3-4 (1) INTERSECTION OF DAVAO-GENERAL SANTOS ROAD (0+000)
(INITIAL STAGE)

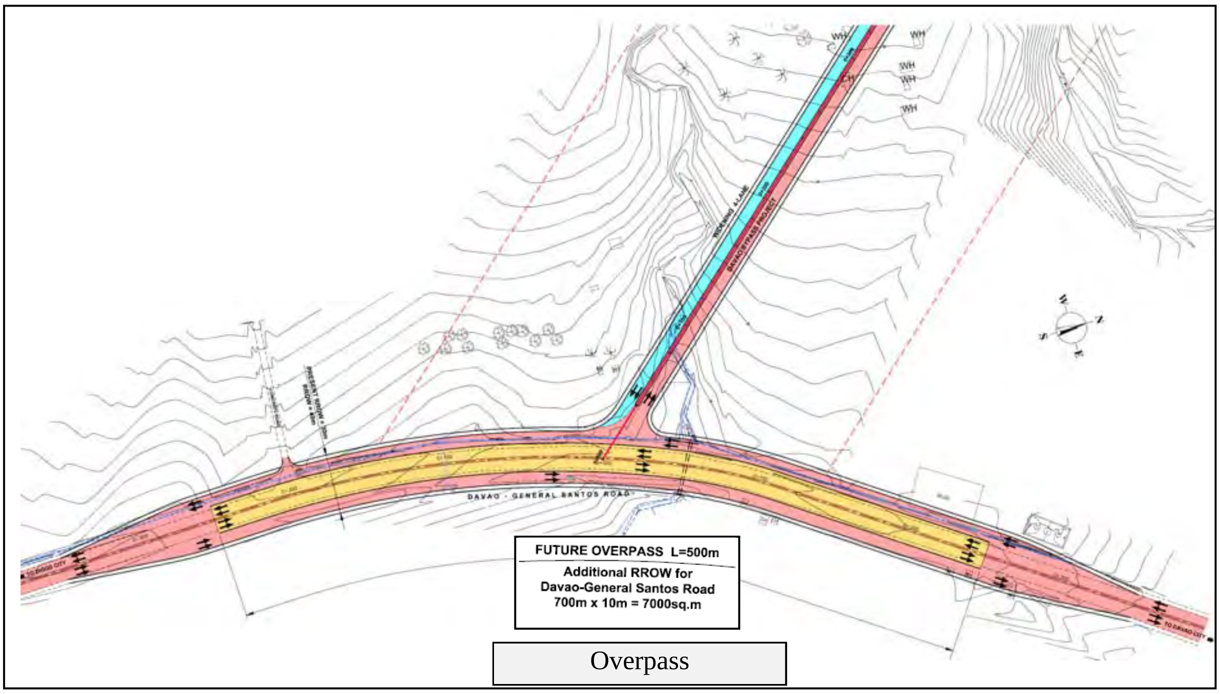


FIGURE 10.3-4 (2) INTERSECTION OF DAVAO-GENERAL SANTOS ROAD (0+000)
(WIDENING STAGE)

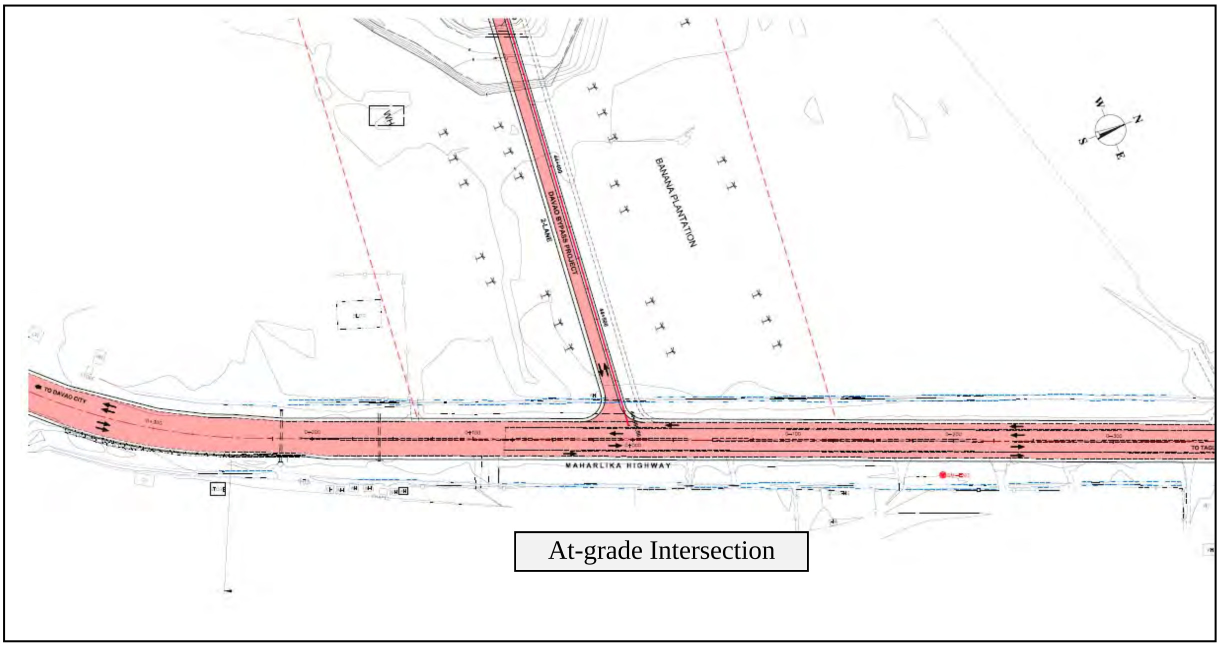


FIGURE 10.3-5 (1) INTERSECTION OF MAHARLIKA HIGHWAY (46+600) (INITIAL STAGE)

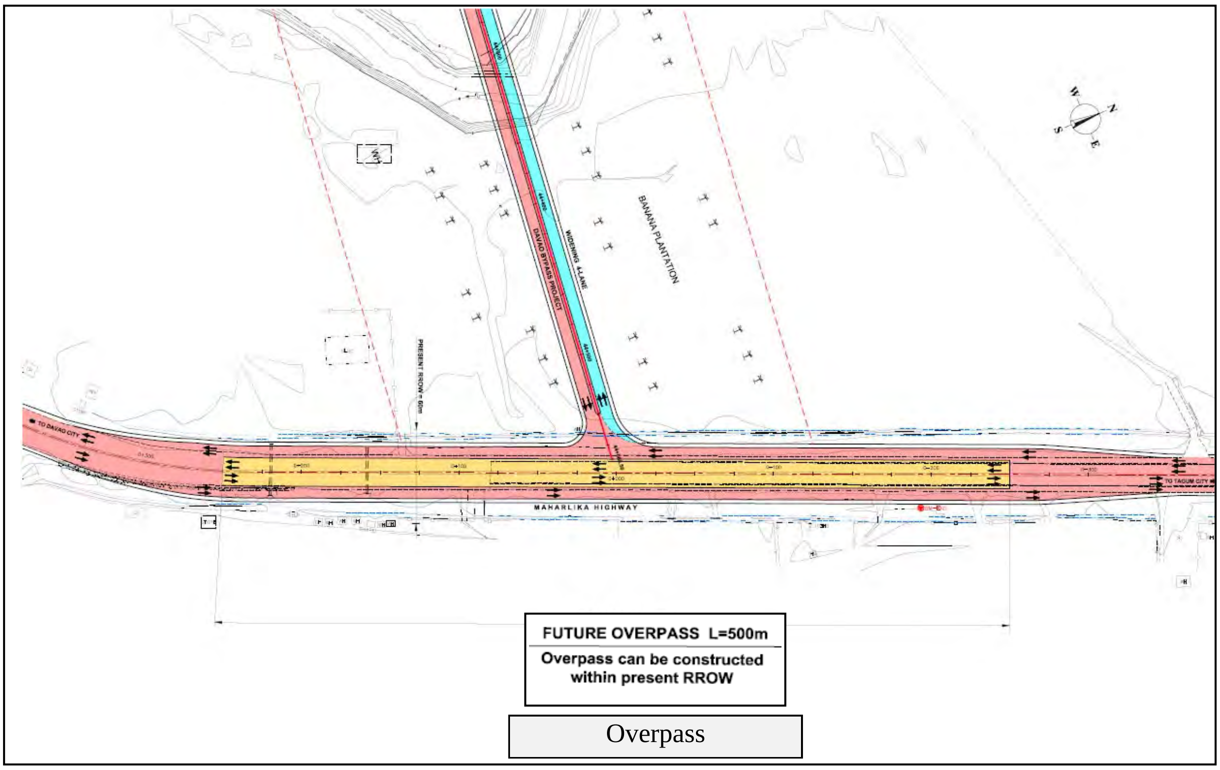


FIGURE 10.3-5 (2) INTERSECTION OF MAHARLIKA HIGHWAY (46+600) (WIDENING STAGE)

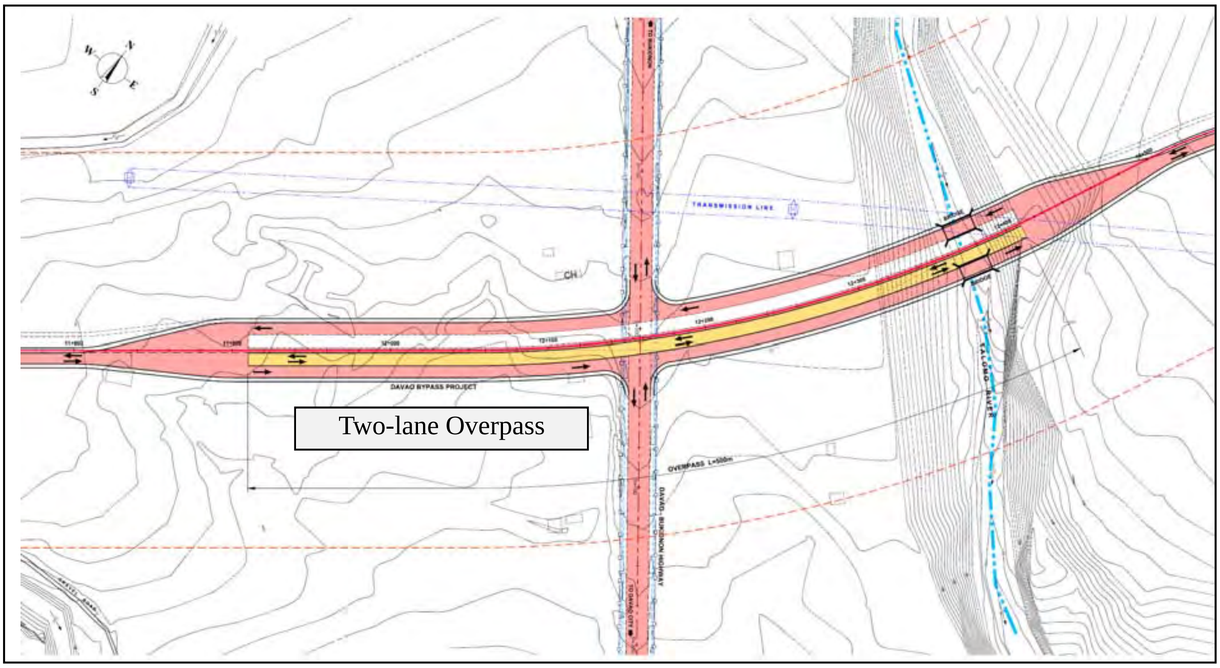


FIGURE 10.3-6 (1) INTERSECTION OF DAVAO-BUKIDNON HIGHWAY (12+150) (INITIAL STAGE)

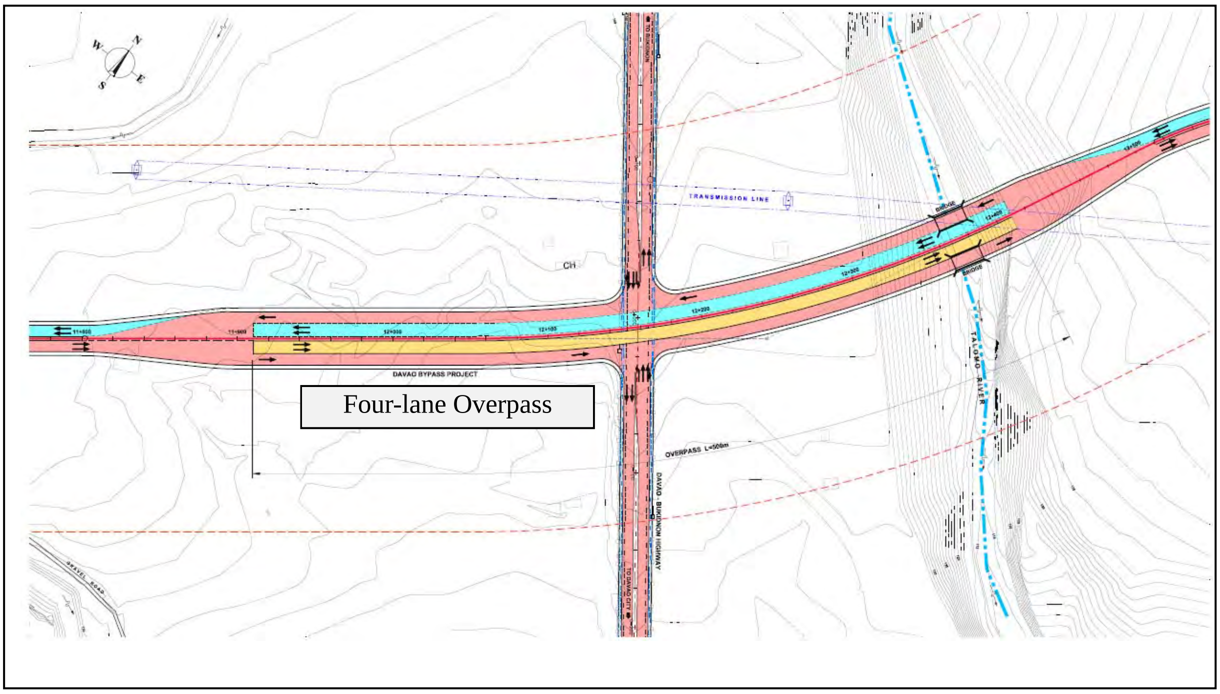


FIGURE 10.3-6 (2) INTERSECTION OF DAVAO-BUKIDNON HIGHWAY (12+150) (INITIAL STAGE)

10.4 TUNNEL DESIGN

The basic tunnel design standards were presented in S**ection 10.2.3**.
Total Tunnel Length: 2,280m (19 + 030 – 21 +310)

- Main Tunnel, 2-lane (1 lane per direction)
- Evacuation Tunnel with evacuation adit (3 @ 30m) and personnel adit (2 @ 30m)

Figure 10.4-1 shows the plan of the tunnel section.

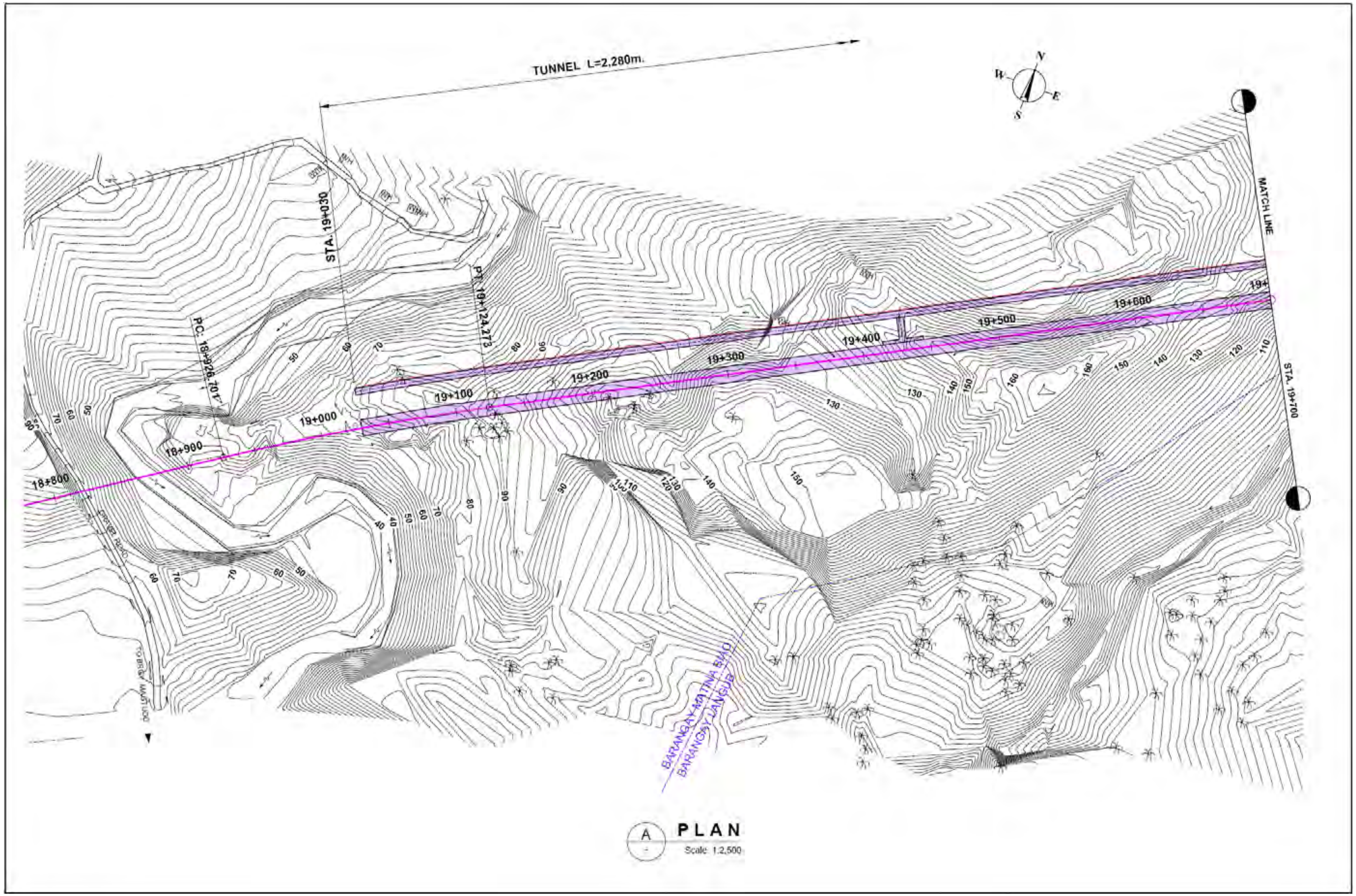


FIGURE 10.4-1 TUNNEL PLAN

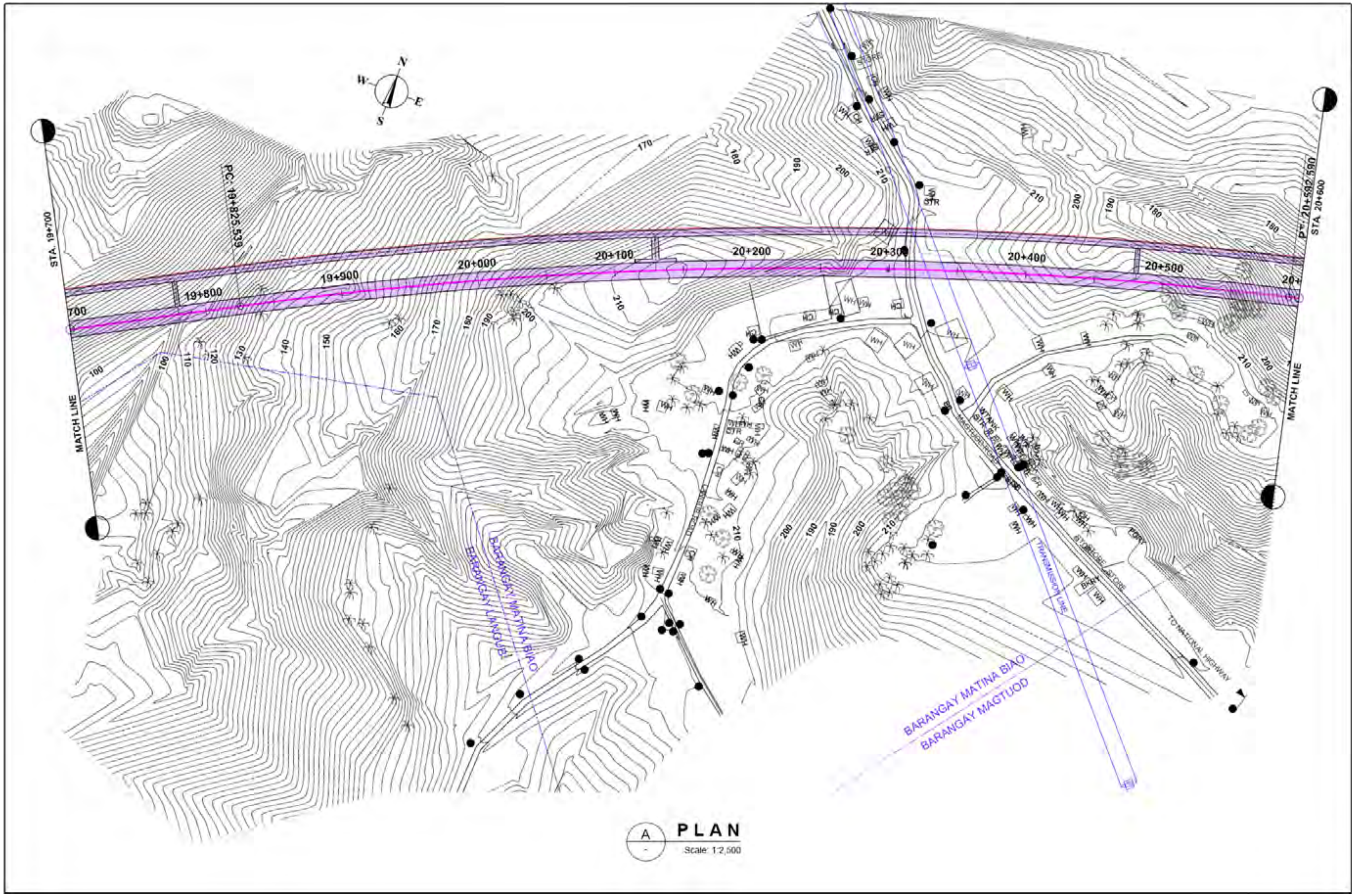


FIGURE 10.4-2 TUNNEL PLAN

FIGURE 10.4-3 TUNNEL PLAN

10.4.1 Main Tunnel Excavation Pattern

Expected geology on the tunnel route by the geological survey showed the geological profile of tunnel design drawings (see **Figure 10.4-4** and **Photo 10.4-1**). Different excavation patterns were suggested as section 3, C2, D1, and D2. As shown in **Table 10.4-1**, four (4) types of typical cross section were prepared. Based on the geological condition, the tunnel invert is necessary for the whole section due to mudstone. C2, D1 and D2 were selected.

TABLE 10.4-1 LENGTH OF TUNNEL EXCAVATION PATTERN

West Side **East Side**

D2	D1	C2	D1	D2	D1	D2	D2
70m	90m	150m	350m	160m	950m	400m	110m
						Total = 2,280m	

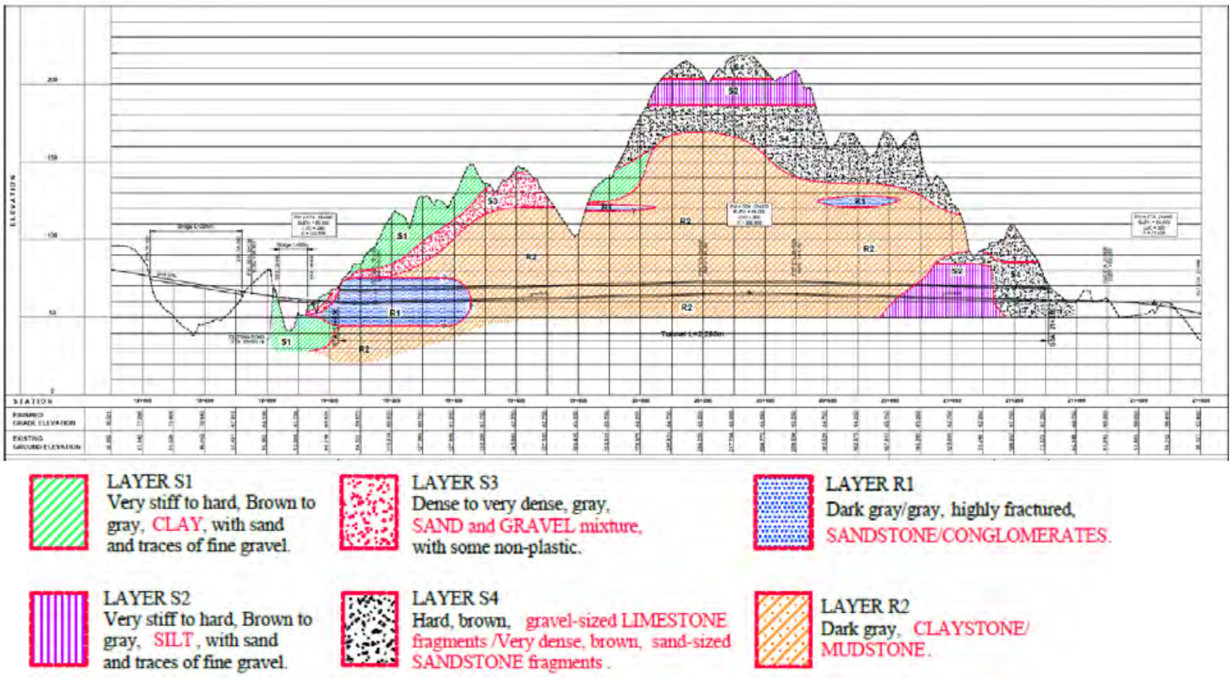


FIGURE 10.4-4 GEOLOGICAL CONDITION ON TUNNEL ROUTE

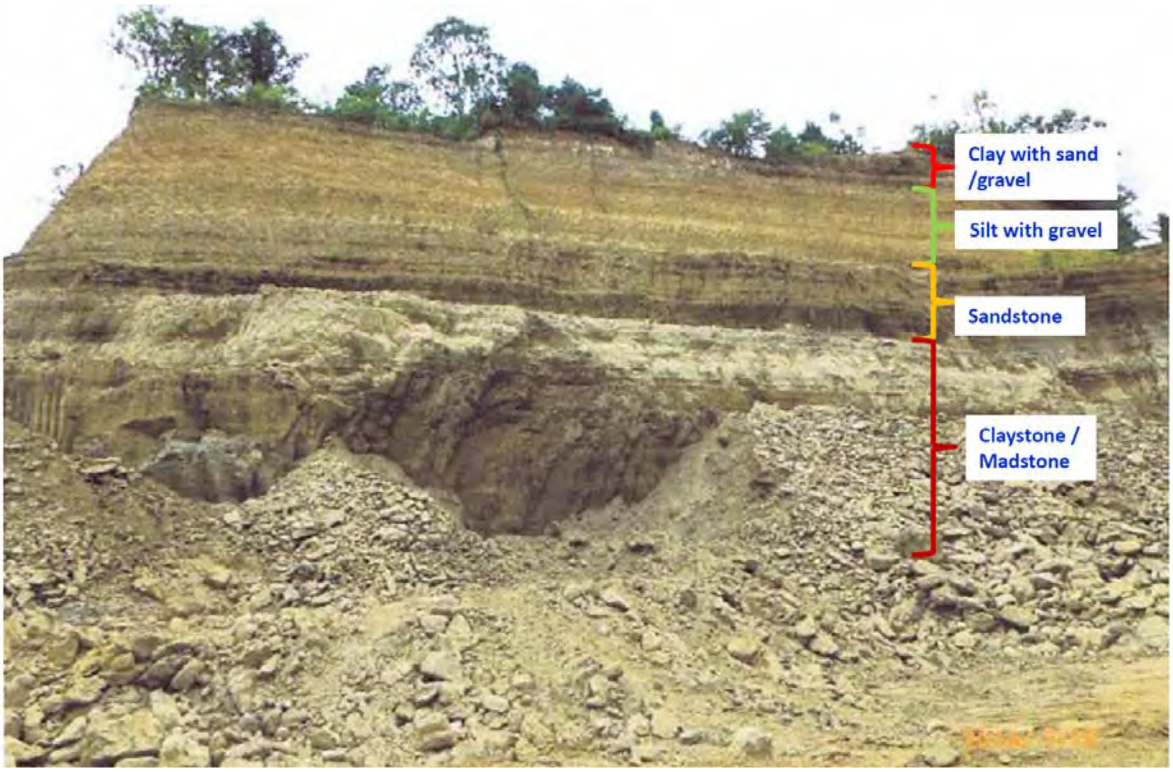


PHOTO 10.4-1 EXCAVATED CONDITION AT QUARRY SITE (ABOUT 1KM AWAY FROM THE TUNNEL SECTION)

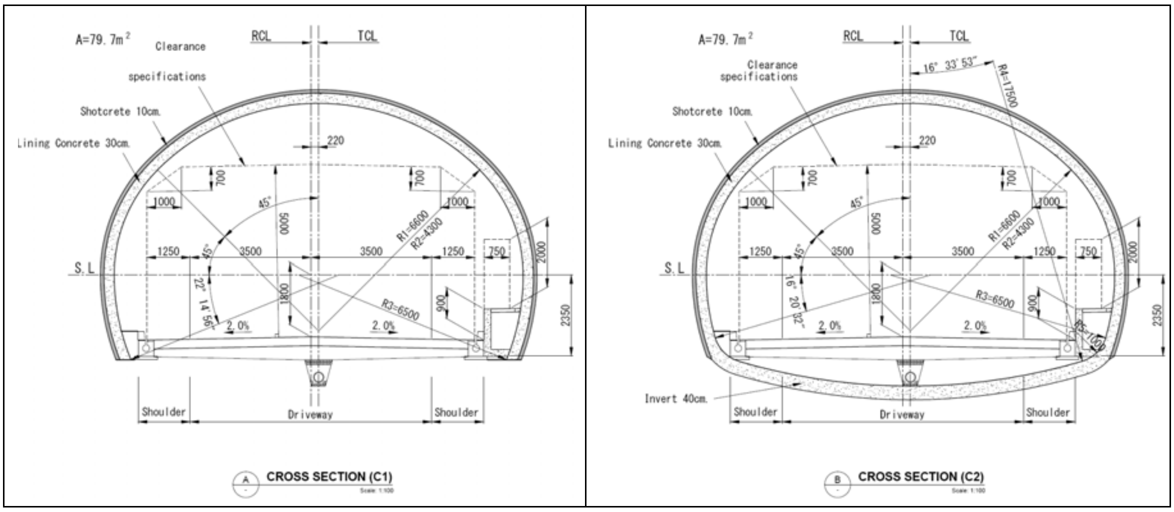


FIGURE 10.4-5 TYPICAL TUNNEL CROSS SECTION (TYPE C)

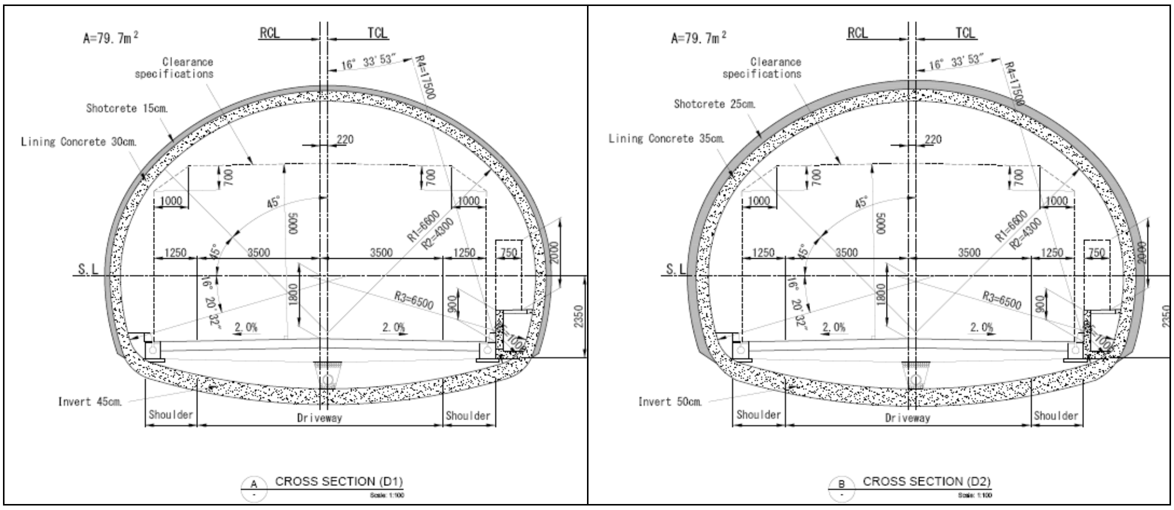


FIGURE 10.4-5   TYPICAL TUNNEL CROSS SECTION (TYPE D)

10.4.2 Tunnel Excavation Method

- Excavation method adopted is conventional NATM. (NATM: New Austrian Tunneling method) based on geological survey results of tunnel route consider the blasting system or mechanical drilling system.
- Mechanical drilling and blasting system for geological criteria uses Japanese bombing scheme. This scheme is economical from over 30Mp of the uni-axial compressive strength of rock.
- Geological condition along tunnel route is considered soft rock ground quality. Therefore, standard excavation method adopted is upper half drilling excavation method for engineering safety and economic efficiency. This excavation Method is shown in **Figure 10.4-6**.
- Efficient management is important item to reduce risks during construction.
- Tunnel drilling soft layer, would require further auxiliary methods. In this case, it require a special construction such as tip of the receive method

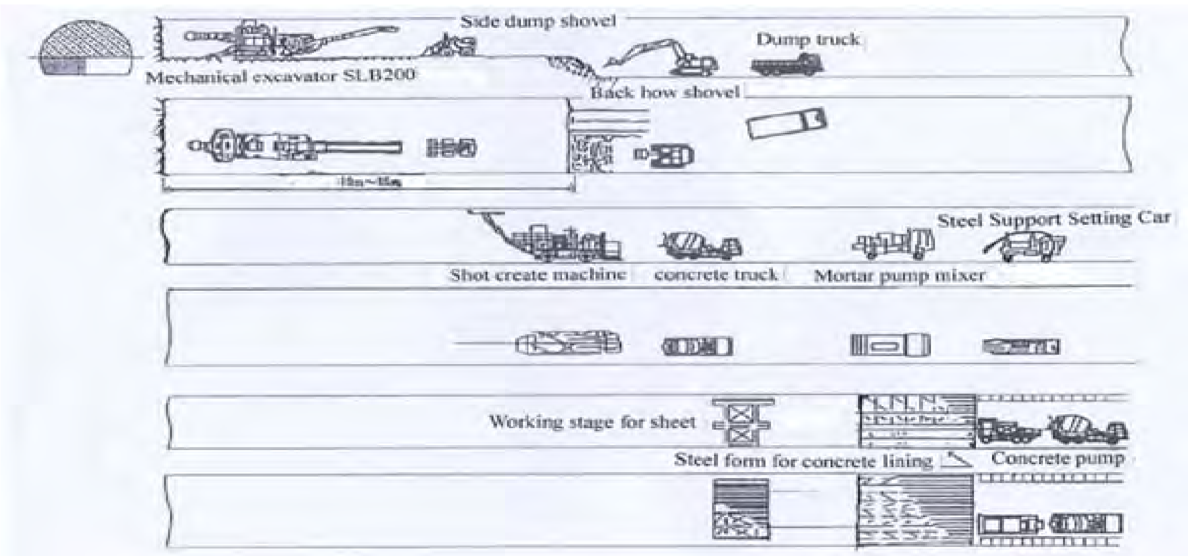


FIGURE 10.4-6 SYSTEM OF EXCAVATION METHOD

(1) Tunnel Excavation Equipment's

Standard facilities and equipment's for tunnel construction are listed in **Table 10.4-2**. Mechanical excavator and breaker machine are used for tunnel excavation, **Table 10.4-3** shows electric consumption of facility and equipment for tunnel construction. 782.0 kW is necessary for the works of tunnel excavation and 648.5 kW is necessary for the works of lining concrete. Accordingly, 4 units of 200KVA generators are necessary.

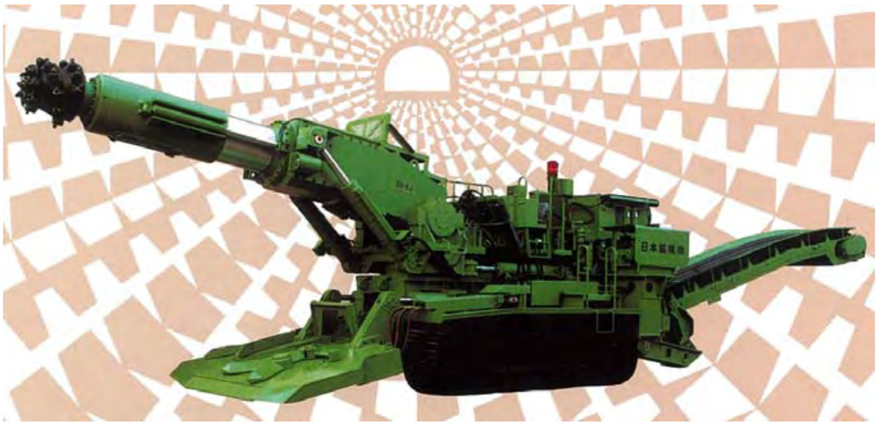
TABLE 10.4-2 TYPICAL FACILITIES AND EQUIPMENT'S FOR TUNNEL CONSTRUCTION

No	Facilities and Equipment's	Quantity (unit)	Motor (kW)	Note
1	Mechanical excavator S200 type	1	300.0	Road Header
2	Dump truck 20t-30t	6		Diesel
3	Side dump shovel	1		Diesel
4	Hydraulic breaker	1		Diesel
5	2-boom Jumbo	1	148.0	
6	Back hoe shovel	1		Diesel
7	Ventilation fan 150kW x 2 motor	1	300.0	Q=1,500 m^3/min
8	Shotcrete machine	1	120.0	
9	Mortar pump mixer	1	5.5	
10	Working stage for sheet	1	7.5	
11	Steel former for concrete lining	1	25.0	L=10.50m
12	Concrete pump	1	75.0	15 m^3/hr
13	Ready mixed concrete truck	4		Diesel
14	Transformer substation truck	1		Diesel
15	Lighting in tunnel	2,100 m	126.0	
16	Lighting outside of tunnel	300Wx10	3.0	
17	Batching plant for concrete	1	35.0	30 m^3/hr
18	Cement Silo 30t	1	5.5	
19	Sand gravel stock yards 200 m^3	3	16.5	
20	Water tank 30t	1	5.5	
21	Mechanical excavator S100 type	1	150	Evacuation TN
22	Shotcrete machine	1	40	
23	Battery units of Battery Locomotive	2	50	
24	Diesel generator 200KVA	4	800	Diesel
25	Electric power station 800KVA	1		
26	Dust-water equipment 40t/hr	1	40.0	Motor
27	Another facility	1	20.0	
	Total of Electric equipment			

TABLE 10.4-3 ELECTRIC POWER REQUIREMENT FOR TUNNEL CONSTRUCTION

Required Electric Power	kW
1. Excavation works	782.0
2. Shotcrete works	648.5
3. Concrete lining works	303.5

Photos below show some Tunnel Construction Machines;



Source : Catalog

PHOTO 10.4-2 ROOD HEADER S-200 TYPE, TOTAL POWER 302.5KW, TOTAL WEIGH 50

Source : Catalog

PHOTO 10.4-3 EXCAVATION BY ROOD HEADER

Also called a partial face machine, A Road Header is a tunneling machine. It is a boom mounted drum with cutting head that revolves to excavate rock or others.

(2) Temporary yard of facilities and equipment's for tunnel construction

Mechanical excavation using both Road Header and Breaker is planned for tunnel excavation, in consideration of the restriction of using electric power.

Standard area of temporary facilities and equipment's are shown in **Table 10.4-4**.

TABLE 10.4-4 STANDARD AREA OF TEMPORARY FACILITIES AND EQUIPMENT'S

	Item	Size（m）	Area（m^2）	No.	Note
1.	Compressor Room	4.0×7.0	28.00	1	
2.	Generator power station	8.5×24.00	204.00	1	
3.	Repair shop	7.2×9.0	64.80	1	
4.	Water supply tank	2.0×5.0	10.00	1	
5.	Turbine Pump	2.0×2.0	4.00	1	
6.	Material stock yard	8.0×15.0	120.00	1	

	Item	Size（m）	Area（㎡）	No.	Note
7.	Concrete mixing plant	8.0×20.0	160.00	1	
8.	Sewerage facilities	5.0×15.0	75.00	1	
9.	Rest room	7.2×9.0	64.80	1	
10.	Supervisor office	4.5×4.5	20.25	1	
11.	Ventilation fan	2.0×6.0	12.00	1	
12.	Muck loader yard	10.0×15.0	150.00	1	
13.	Warehouse	7.0×10.0	70.00	1	
14.	Gantry crane yard	7.0×10.0	70.00	1	
15.	Carriage-way space	8.0×100.0	800.00	1	
16.	Muck stock yard	20.0x40.0	800.00	1	
	Total		2,652.85		

Temporary yard shall be wider than the above area, approximately 30m x 100m = 3,000 ㎡ is necessary for temporary yard. Typical temporary facility plan for tunnel construction is shown in **Figure 10.4-7**.

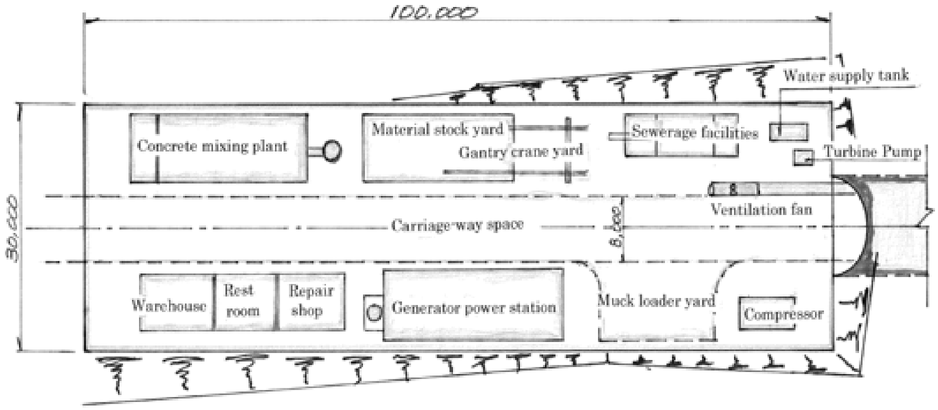


FIGURE 10.4-7 PLAN THE TYPICAL TEMPORARY FACILITIES

Electric Power Station and Receiving Box

Sewerage Facilities

Dust Water Filter Equipment

Generator Room for Tunnel Construction

Steel Supports Setting Equipment

Entrance of Under Construction Tunnel

All Sources of Photo: Japan Highway Corporation

(3) Works of Tunnel Lining Concrete

1) Steel Form

Following the tunnel excavation, shotcrete, rock bolts and secondary lining concrete as a permanent structure are undertaken. As for the assembly scheme framework, the steel panel of the framework (the arch centre component) is dismantled every time for one span for concrete placing and assembled again for the next concrete placing. These repeated works for the assembling and dismantling need time resulting in the poor progress for concrete lining. The form is shrinkable by extending to up and down, left and right with the jack of hydraulic type and the movement of framework is smooth for every concrete placing. This portable scheme framework is currently used for tunnel lining. The standard length of one framework is 12.0m.

PHOTO 10.4-4 SLIDING STEEL FORM

2) Lining Concrete

Challenges encountered during tunnel concrete construction management include the following items.

① Concrete finish at temperatures reaching 40 degrees Celsius. Resignation of the hair racks of drying shrinkage.

② Concrete honey real property loss due to lack of consolidation, and material separation Cavity occurs due to lack of concrete back fill.

To solve these problems, the Nippon Expressway Corporation (NEXCO) has developed the middle-performance lining concrete. It is proposed to the Davao Bypass Tunnel to adopt this method. It is tighter and of higher quality than the conventional concrete lining

(4) Auxiliary Method for Excavation of Tunnel Entrance

Entrance of tunnel Construction for mountain area is geologically unconsolidated ground range which is composed of sand, clays and gravels. It is necessary to use auxiliary method which is All Ground Fasten (AGF) Method shown in **Figure 10.4-8**.

1) AGF Method

Long steel pipe approximately φ100mm tubes are driven into outer surrounding area of the excavation face of tunnel. Then SRF is injected to improve the zone between the steel pipe, stabilized the working face, and prevent surface ground subsidence. Reliable effect can be expected under various fragile conditions ranging from clayey Soil to finely cracked rock.

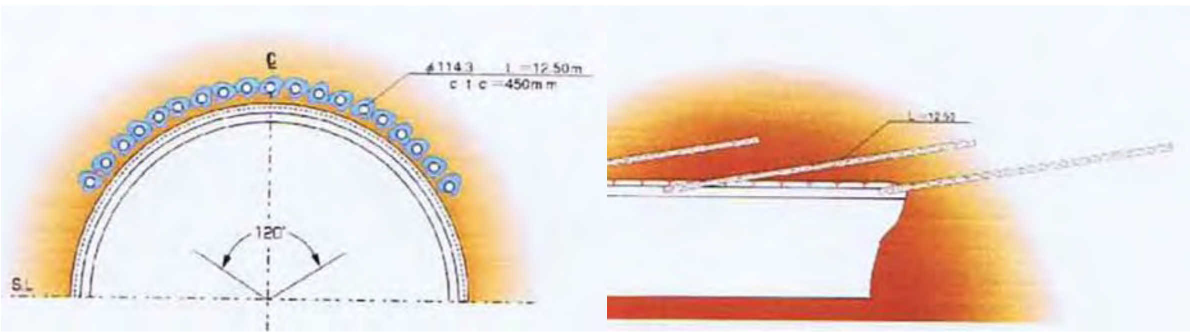


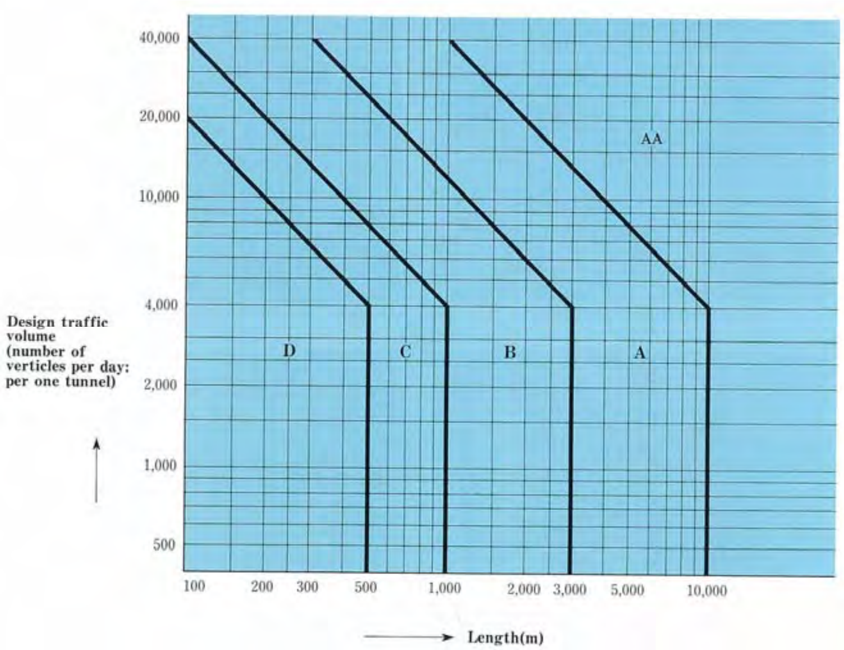
FIGURE 10.4-8 AGF – PIPE LOOP METHOD

For the proposed Davao Bypass Project, sections to adopt this method are both the East and West portals and the eastern section with a minimum earth covering of 20m.

West portal side	STA. 19+030 ~ STA. 19+100	70m
East portal side	STA. 21+030 ~ STA. 21+100	70m
	STA. 21+200 ~ STA. 21+310	110m
	Total	250m

10.4.3 Tunnel Facilities based on Classification of Tunnels

Tunnel Facilities and Emergency Facilities are also important items in road tunnels. Tunnels provide emergency Facilities based on the tunnel classification (length of tunnel and traffic volume) for traffic safety to minimize the occurrence of accidents. Based on **Figure 10.4-9**, Davao Bypass Tunnel is classified as category A.



Source: Japan Standard for Mountain Tunneling

FIGURE 10.4-9 JAPAN STANDARD CLASSIFICATION OF TUNNELS

Each tunnel shall be equipped with emergency facilities listed in **Table 10.4-5** in accordance with the CLASS of tunnel. This is for the prevention of traffic accidents and disaster mitigation as well as danger in cases of other emergencies.

TABLE 10.4-5 JAPAN STANDARD OF EMERGENCY FACILITIES TO BE INSTALLED

Emergency Fcilities			Classfication of tunnel: AA	A	B	C	D	Remarks
Information and alarm equipment	Emergency telephone		O	O	O	O	O	Omitted in class D tunnel less than 200m in length.
	Pushbutton		O	O	O	O		
	Fire detector		O	O				Omitted without ventilation system
	Emergency alarm equipment	Tunnel entrance information board	O	O	O	O	O	Omitted in tunnels less than 200m in length
		In tunnel information board	O	△				To be installed in class A tunnels 3,000m or more in length
Fire facilities	Fire exinguisher		O	O	O	O	O	
	Fire plug		O	O	△			To be installed in class B tunnels 1,000m or more in length
Escape and guidance equipment	Guide board	Emergency exit lamp	To be installed in tunnel with evacuation adits					
		Guide board (A)	To be installed in tunnel with evacuation adits					
		Emergency exit board	To be installed in tunnel with evacuation adits					
		Guide board (B)	O	O	O			To be installed in tunnels Without evacuation adits.
	Smoke discharge equipment and Escape passage		･Evacuation adits to be provided in tunnels of around 750m or more in length. ･Smpke discharge equipment to be provided in tunnel of around 1,500m or more in length. ･Evacuation tunnels provided for those Class AA tunnels and ClassA tunnels of a length 0f 3,000m or more which employ a two-way traffic system and a longitudinal ventilation system in which the length of one ventilation section is more than 2,000m.					
Other equipment	Hydrant		O	O	△			To be provided in ClassB tunnels 1,000m or more in length. Tunnels equipped with hydrants are to be provided with a water supply ports near the entrance.
	Radio communication auxiliary equipment	Leakage coaxial cables	O	△				To be provided in ClassA tunnels 3,000m or more in length.
		Entrance telephone	O	O				Entrances/Exit
	Radio rebroadcast equipment	Interrupt function provided	O	△				To be provided in ClassA tunnels 3,000m or more in length.
	Loudspeaker equipment		To be provided in tunnel equipped with a radio rebroadcasting equipment (with interruption function).					
	Water sprinkler system		O					To be provided in ClassA tunnels 3,000m or more in length. And serviced in two way traffic.
	Observation	Type A (200m intervals)	To be provided in tunnels with water sprinkler.					
		Type B (emergency parking area)		△				To be provided in Class A tunnels 3,000m or more in length.
	Lighting equipment for power failure		To be provided in tunnels 200m or more in length					
	Emergency power supply equipment	Independent power plant	To be provided in tunnels 500m or more in length					
		Non-failure power supply equipment	To be provided in tunnels 200m or more in length					

Notes: O Mandatory (standard) △ Recommended

Source: Japan Society of Civil Engineers

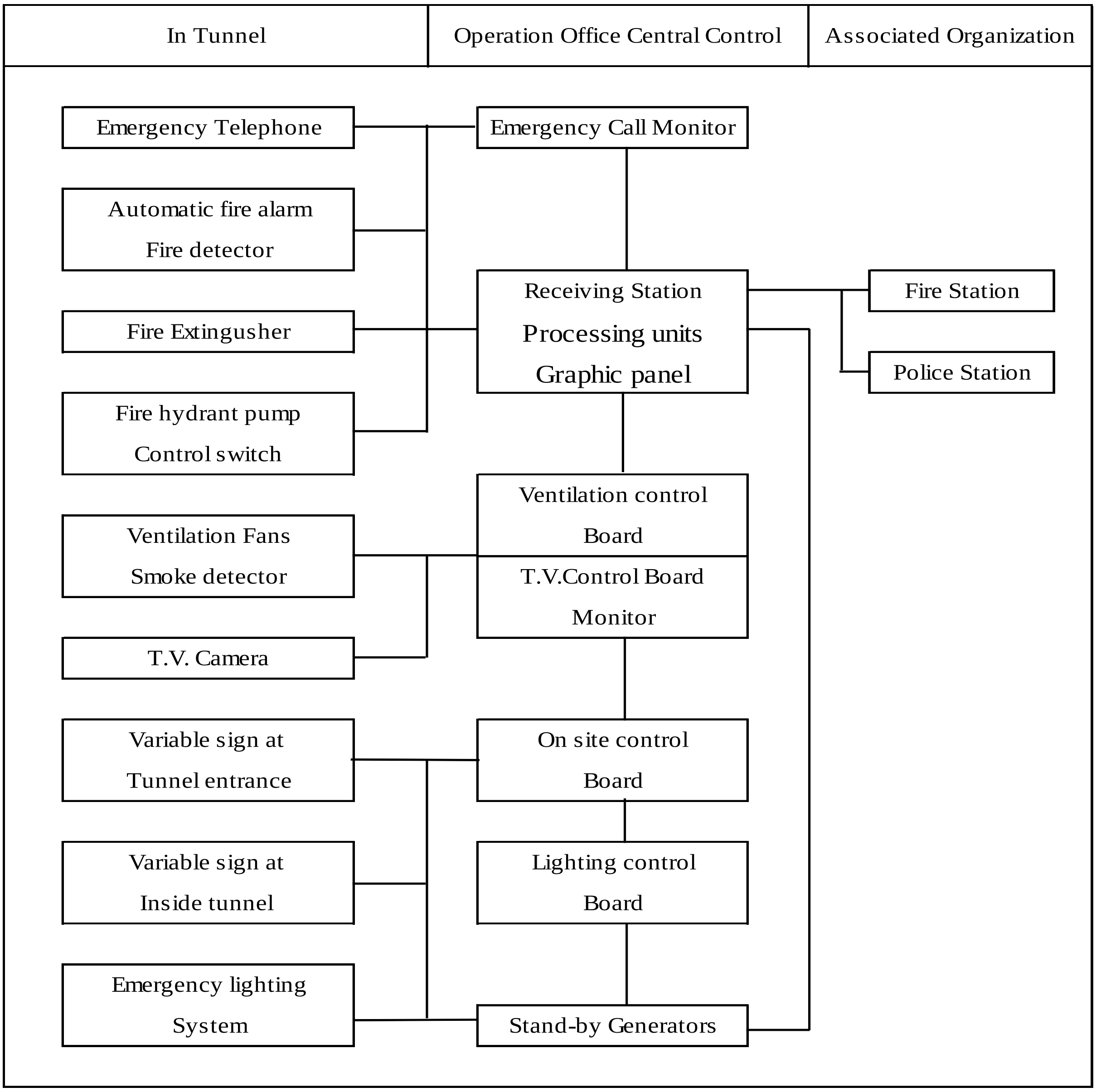
10.4.4 Operation System for Emergency Facilities

Emergency systems are designed so that all the available facilities and functions are integrated to provide an efficient and rapid response to traffic accidents in the tunnel. An accident in the tunnel is generally reported by emergency telephones and push button equipment or CCTV monitoring. Fire is automatically reported by fire detectors.

Notification of an emergency is received first by the switchboard of the central control and is transmitted to the administration office in-charge.

The schematic layout of a typical tunnel operation is shown in **Table 10.4-6.**

TABLE 10.4-6 LAYOUT OF A TYPICAL TUNNEL OPERATION



Source: JICA Study Team

Action flow of each accident type is shown in the **Figure 10.4-10**.

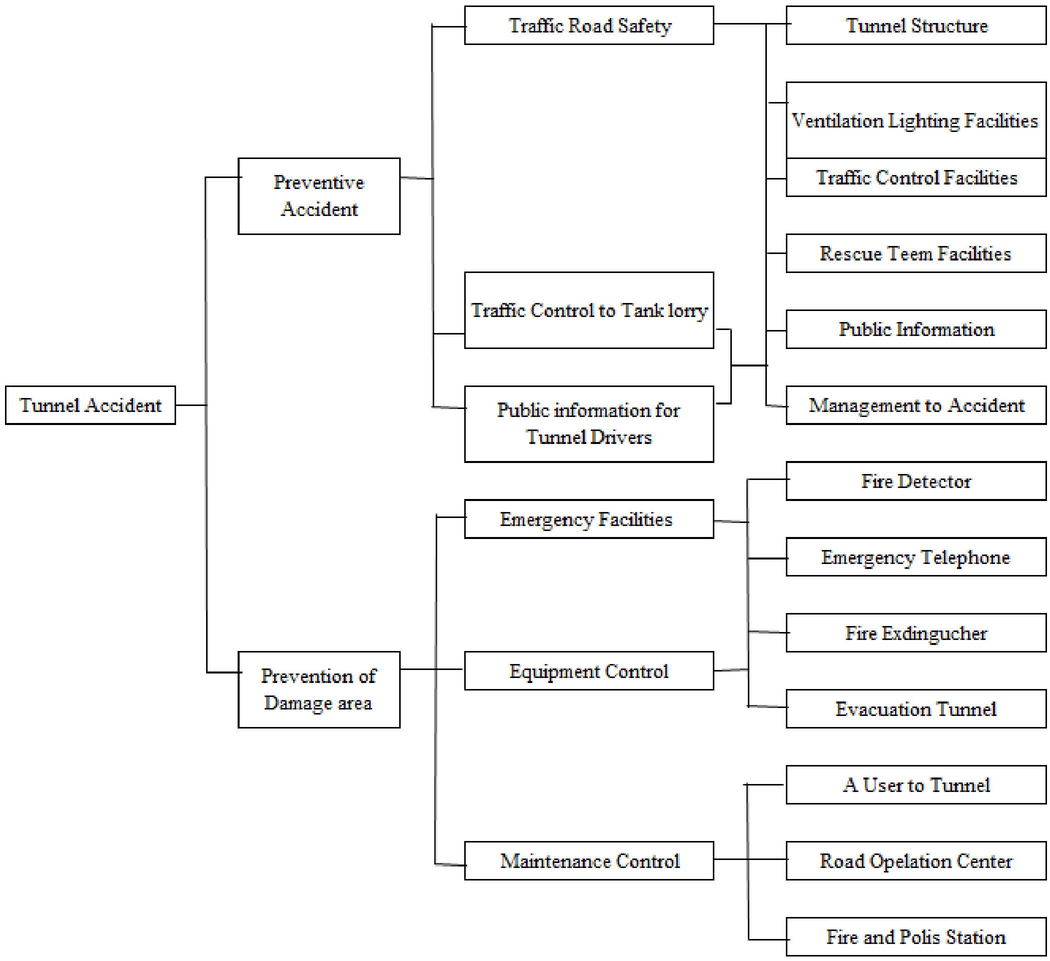


FIGURE 10.4-10 EACH COMPONENT FLOW OF TUNNEL ACCIDENT

(1) Evacuation Tunnel Plan

In case of accidents, road users must determine the situation and do something for evacuation from the tunnel. The facilities especially for emergency exits, user escape from accident point in the tunnel. In this case set up evacuation tunnel shall be established in 2,280 m length of Davao Bypass tunnel. Below photo shows evacuation exit and evacuation tunnel.

Evacuation Exit

Evacuation Tunnel

Source: Japan Highway Corporation

- **Cross Section of Evacuation Tunnel**

Cross section and layout plan for evacuation tunnel is shown in **Figure 10.4-11** and **Figure 10.4-12**. This evacuation tunnel allows for use by small fire vehicle, ambulance vehicle and management vehicle.

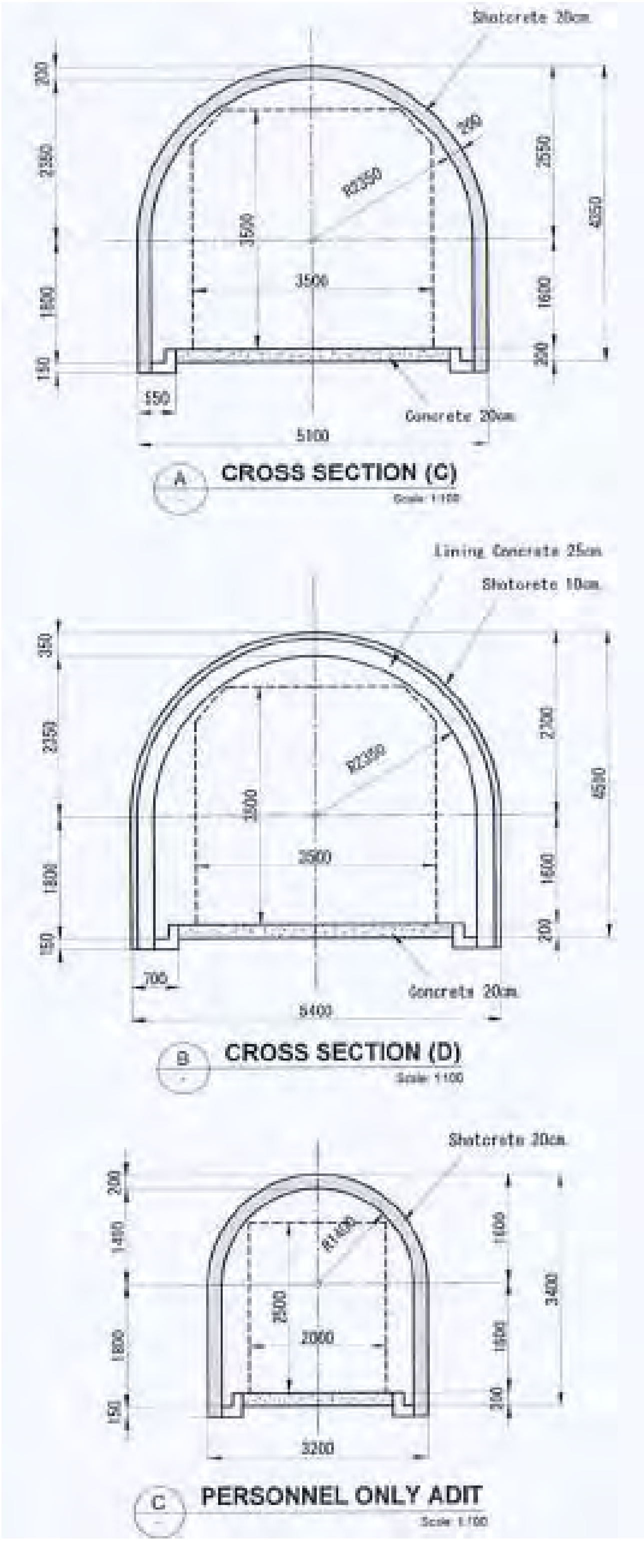


FIGURE 10.4-11 CROSS SECTION OF EVACUATION TUNNEL

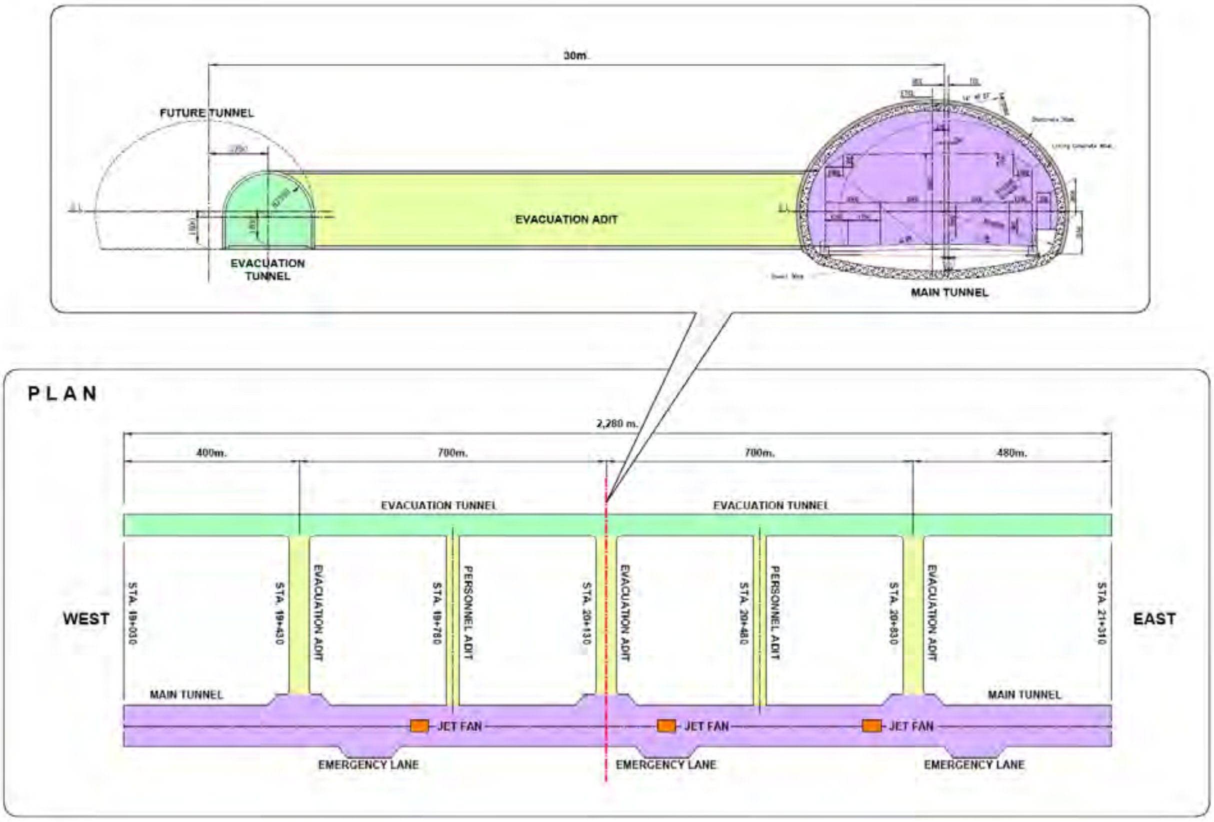
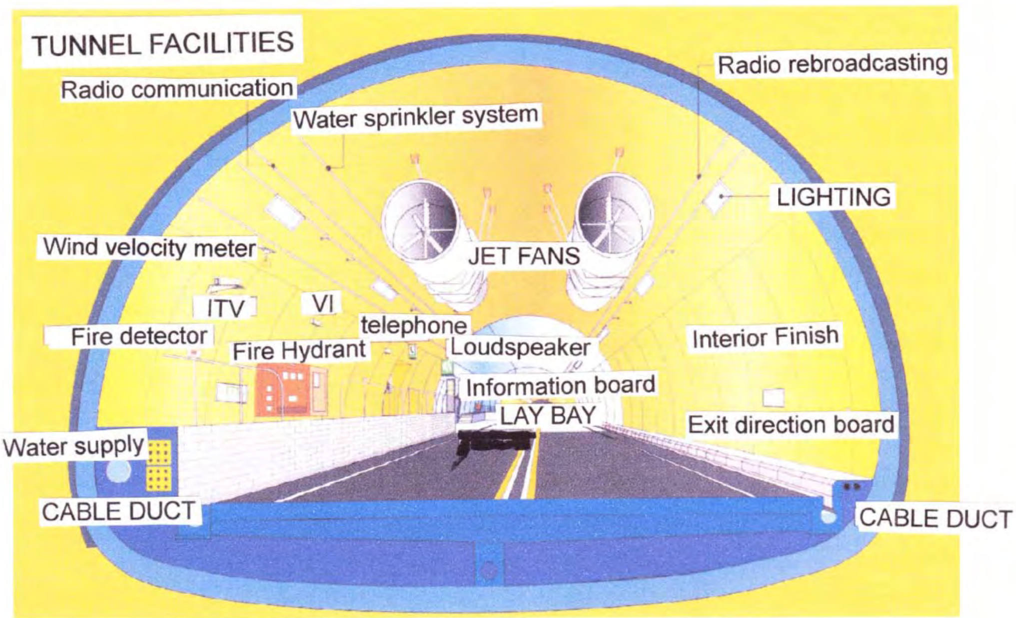


FIGURE 10.4-12 LAYOUT PLAN FOR EVACUATION TUNNEL

10.4.5 Tunnel Facilities

Typical layout of Tunnel Facilities is shown in **Figure 10.4-13.**



Source: Japan Highway Corporation

FIGURE 10.4-13 TUNNEL FACILITIES INSIDE

Source: Japan Highway Corporation

FIGURE 10.4-14 VARIABLE INFORMATION SIGNBOARD (TYPE-D)

(1) Tunnel Ventilation System

Exhaust Gas from vehicle contains Carbon monoxide (CO) and soot which are harmful to the human body. Therefore it is necessary to install ventilation system for more than 500m length of tunnel to remove exhaust gas from vehicles.

1) Guideline for Natural Ventilation

There are two kinds of ventilation systems: the natural ventilation system and the mechanical ventilation system.

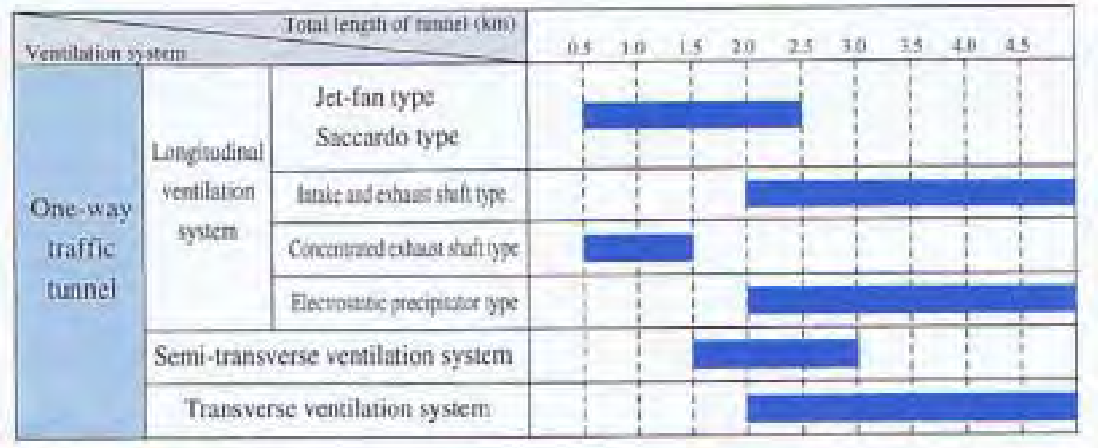
The following formula gives a guideline for border of using either natural ventilation or mechanical ventilation;

Two-way traffic (2 lanes): $L \cdot N \geq 600$
One-way traffic (2 lanes): $L \cdot N \geq 2000$
Where L: Total Length of Tunnel (km)
N: Traffic volume (veh/h)

2) Guideline for Mechanical Ventilation System

The mechanical ventilation system is divided into four (4) basic systems which are the longitudinal flow system, the transverse flow system, the semi-transverse flow system, and combination of these systems. **Table 10.4-7** shows the applicable ventilation system based on tunnel length.

TABLE 10.4-7 TUNNEL LENGTHS AND APPLICABLE VENTILATION SYSTEMS



- **Longitudinal ventilation system:** a system where the air is introduces to or removed from the tunnel roadway at a limited number of points, thus creating a longitudinal airflow within the tunnel. There are two (2) distinct types of tunnel longitudinal ventilation systems: those that employ an injection of air into the tunnel from centrally located fans; and those which use jet fans mounted within the tunnel cross-section.
- **Transverse ventilation system: It is defined by the uniform distribution of fresh air and/or uniform collection of vitiated air along the length of the tunnel**. Space for ventilation duct is provided separately. Mechanical Ventilation sends fresh air across the roadway space from the air supply duct.
- **Semi-transverse ventilation system: Chief characteristic is the uniform distribution of collection of air throughout the length of a tunnel**. The roadway space uses two ventilation ducts of the transverse type and only one separate duct is needed. This system is more economical than the transverse system.

The typical ventilation systems are shown in **Figure 10.4-15** to **Figure 10.4-20**. The longitudinal ventilation system for the tunnel is adopted for many countries. It is utilization of traffic ventilation force produced by running vehicles and natural wind induced by difference in atmospheric pressure and temperature between both outside and inside of a Tunnel.

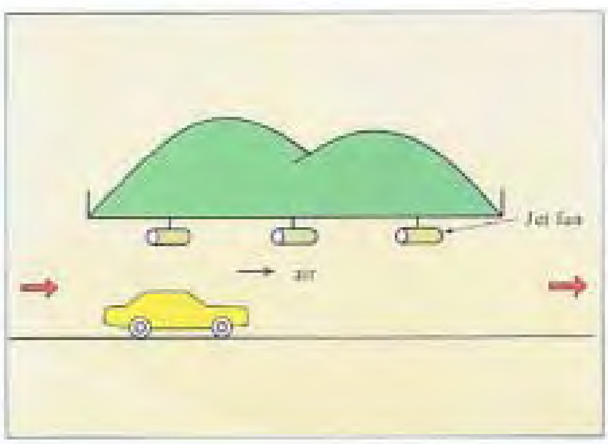


FIGURE 10.4-15 LONGITUDINAL VENTILATION SYSTEM (JET – FAN TYPE)

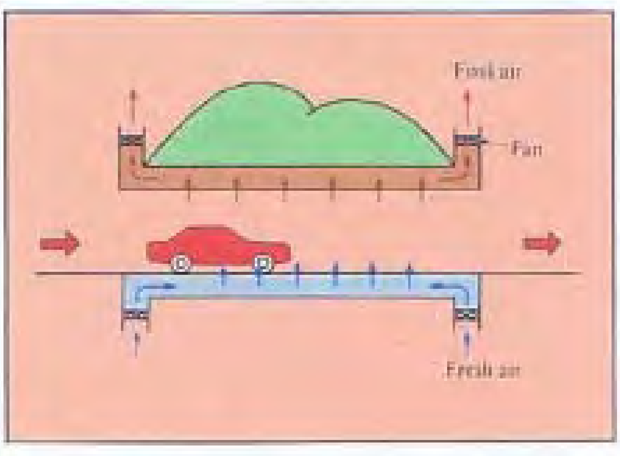


FIGURE 10.4-16 TRANSVERSE VENTILATION SYSTEM

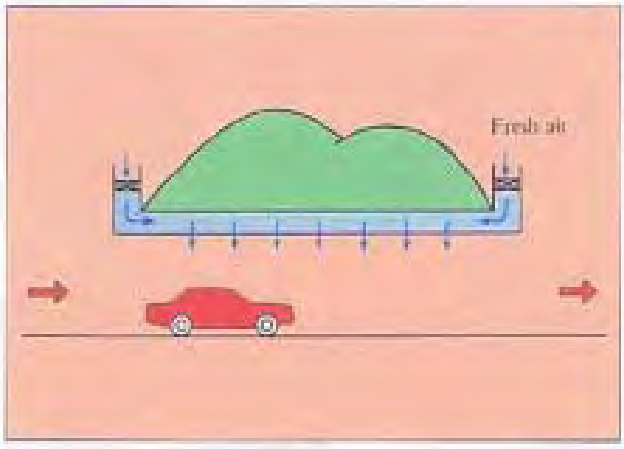


FIGURE 10.4-17 SEMI-TRANSVERSE VENTILATION SYSTEM

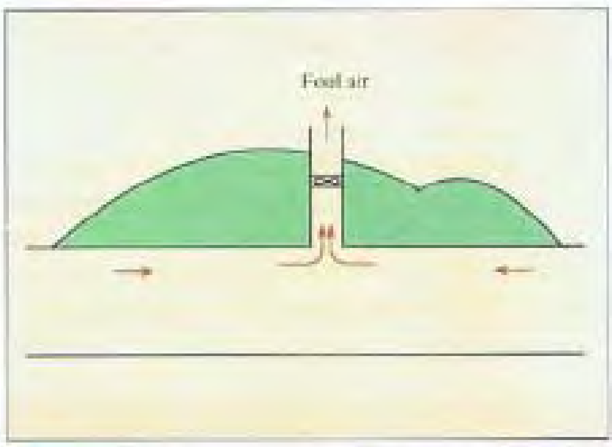


FIGURE 10.4-18 VENTILATION SYSTEM WITH VERTICAL SHAFT (EXHAUST SYSTEM)

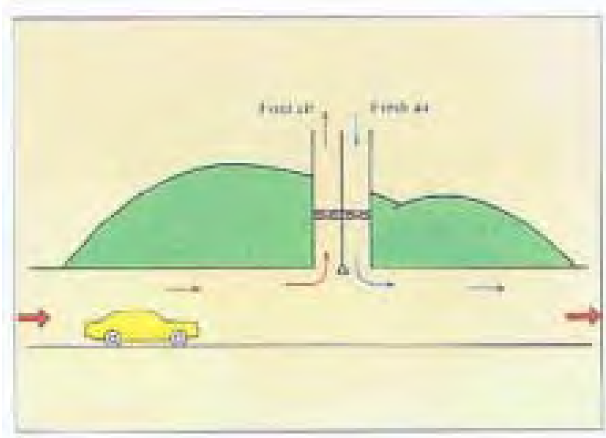


FIGURE 10.4-19 VERTICAL SHAFT TYPE (AIR SUPPLY SYSTEM)

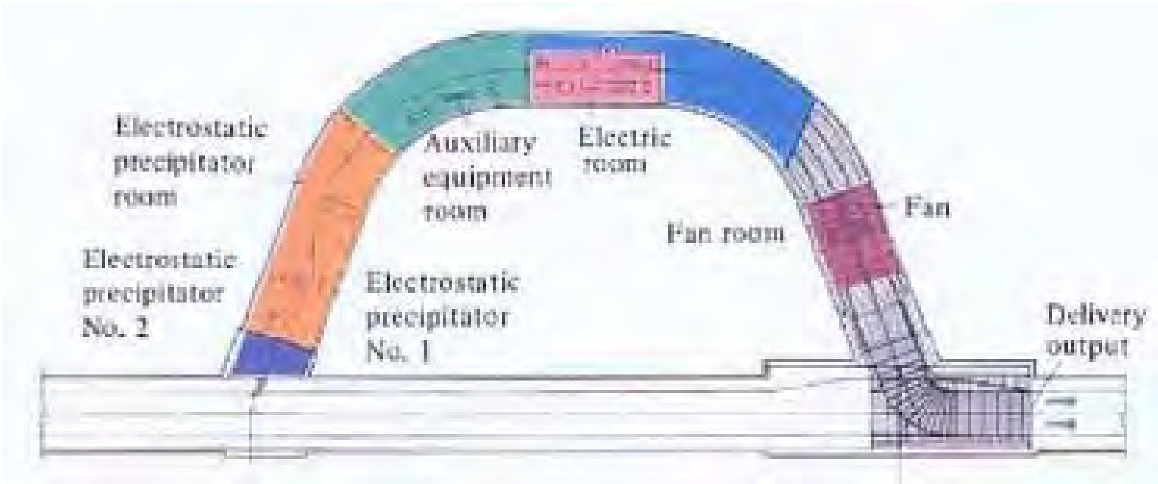


FIGURE 10.4-20 ELECTROSTATIC PRECIPITATOR SYSTEM FRESH AIR REQUIREMENT

The fresh air requirement is based on dilute the CO and soot discharge from vehicle running through the tunnel. The fresh air requirement is obtained as follows:

Fresh air requirement $Q = K \times Qo$

$K = K1 \times K2$

$Qo = q \times N \times L$

Where:

Qo : standard fresh air volume (m^3/s)

K : correction coefficient for speed, longitudinal grade and altitude

K1 : correction coefficient for speed and grade

K2 : correction coefficient for altitude

q : ventilation volume coefficient

N : traffic volume (veh/h)

L : total length of tunnel (km)

Several values need actual calculation.

The unit exhaust rates of soot and CO for Fresh air requirement are shown in **Table 10.4-8** and **Table 10.4-9**, respectively.

TABLE 10.4-8 UNIT EXHAUST RATE OF SOOT AND CO

Type of Vehicle	Unit exhaust rate for soot		Unit exhaust Rate for CO (1/veh/km)
	Average μ (m^2/veh/km)	Standard Deviation S σ (m^2/veh/km)	
Commercial vehicle	2.2	1.0	7.0
Passenger vehicle	0.2	0.3	7.0

TABLE 10.4-9 DESIGN CRITERIA OF SOOT AND CO

Design Speed of Road		For soot (visibility)		For CO Gas
		When reached estimated Hourly traffic volume	When reached potential Traffic capacity	
100 km/h		τ = 50%	τ = 50%	K = 100ppm
80 km/h		τ = 50%	τ = 45%	
60 km/h		τ = 40%	τ = 40%	
When temporary Service in Two-way traffic (Regulated speed)	70 km/h	τ = 45%	τ = 30%	
	60 km/h	τ = 40%	τ = 30%	

It is apparent that the majority of the soot is discharged from commercial vehicles. It is also noted that values are fixed correspondingly to combinations of design speeds and traffic volumes.

(2) Tunnel lighting facilities

Lighting facilities provide a very effective and safe driving and prevents traffic accidents in tunnel.

1) Tunnel Lighting Configuration

Tunnel lighting facilities consist of basic lighting for entrance and emergency lighting systems. Basic schematic tunnel lighting plan is shown in **Figure 10.4-21**.

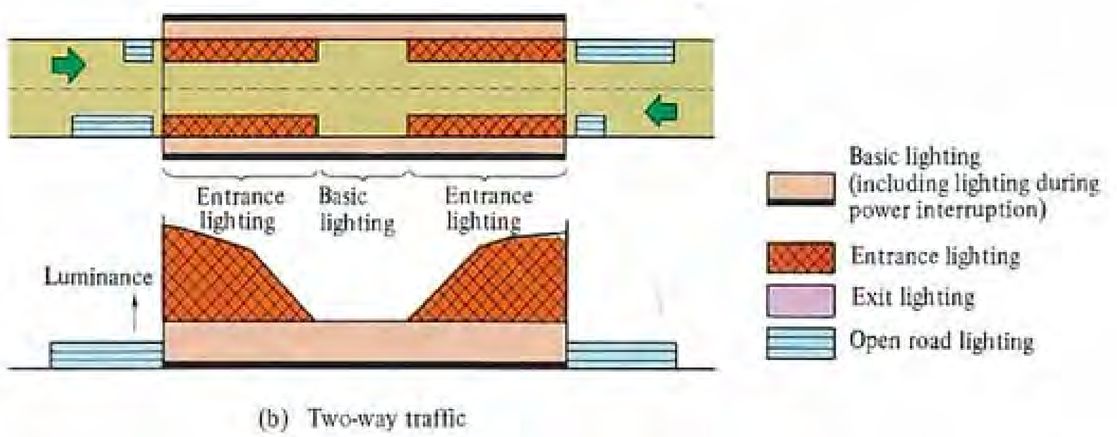


FIGURE 10.4-21 BASIC SCHEMATIC TUNNEL LIGHTING PLAN

2) Basic Lighting

The basic lighting provides drivers with the luminance required to visually perceive obstacles. Lights are distributed evenly along the entire length of the tunnel. Average road surface luminance is specified as shown in **Table 10.4-10**.

The table shows the relationships between vehicle speed and necessary average road surface luminance in ordinary tunnel under 50% light transmittance per 100m.

TABLE 10.4-10 AVERAGE ROAD SURFACE LUMINANCE

Design speed (km/h)	Average road surface luminance (cd/m²)
100	9.0
80	4.5
60	2.3
40	1.5

1) Control of Tunnel Lighting

The entrance lighting and the inside tunnel basic lighting are controlled independently. The entrance lighting is controlled in four steps according to the luminance of the entrance to outside tunnel road.

The basic lighting is controlled in three steps according to the traffic volume and the luminance of the road. Tunnel lighting is controlled automatically by a photocell with a timer installed at the entrance of the tunnel. It also can be controlled from the operation office.

PHOTO 10.4-5 BASIC LIGHTING

(3) Radio broadcast relay system

This system is used to relay AM signals into tunnels, so drivers can catch them without interruption while in the tunnels. Tunnels with a length of 150 meters or over are usually equipped with this system.

(4) Road telecommunications facilities

Highway is equipped with traffic information gathering and providing facilities, such as variable road information signboards, and road lighting facilities.

(5) Emergency Telephone

Emergency telephones are installed on the road side wall in tunnels to permit an immediate emergency call for traffic accident to the road administrator office. The emergency message can be transferred by the switch board to the Police station and Fire station.

Source: Japan Highway Corporation

PHOTO 10.4-6 INDUCTION CABLE

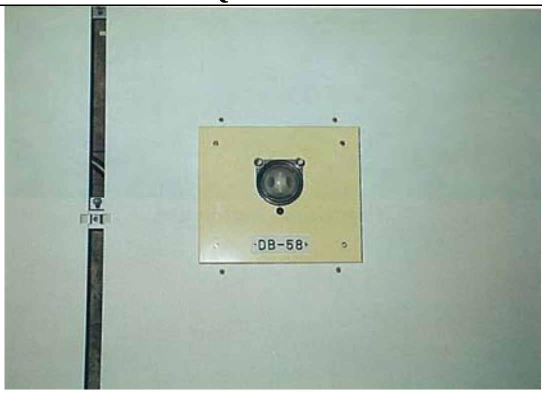
(6) Photo for Basic Tunnel Facilities

VARIABLE INFORMATION SIGNBOARD (TYPE-E)

EMERGENCY TELEPHONE

PUSH-BUTTON NOTIFICATION EQUIPMENT

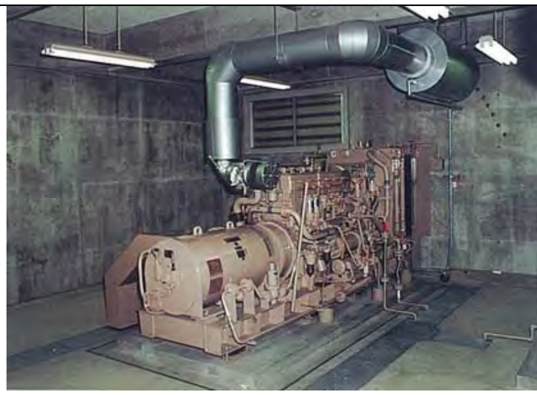
FIRE HYDRANT



AUTOMATIC FIRE DETECTOR


CCTV

DIRECTIONAL SIGNBOARDS


GENERATOR (UNINTERRUPTED POWER SUPPLY)

Source: Japan Highway Corporation

10.4.6 Toll Collection Facility

In order to secure the tunnel O & M cost, toll collection facilities was designed.

(1) Required Toll Booth Number

In accordance with traffic demand forecast (see section 6.2), the required toll booth was calculated. Toll Booth will be installed eastside near Davao River. It has enough road space for toll booth and tunnel management office.

TABLE 10.4-11 PEAK HOUR TRAFFIC VOLUME AT TUNNEL SECTION

	AADT 2033 (a)	Peak hour (b)	Peak Traffic Volume(c= a × b)
Eastbound	5,100 veh /day	8 %	464 veh/hr
Westbound	6,800 veh/day	8 %	544 veh/hr

In Japan, the average service time at toll gate is 8 second in case of flat rate. **TABLE 10.4-12**shows the required toll booth, service time and average waiting vehicle at gate. As peak traffic volume is 464 ~ 544, the minimum required toll gate is two (2) booths for average one waiting vehicle level. The study team recommended three (3) booths for both side considering one spare booth.

TABLE 10.4-12 SERVICE TIME, AVERAGE WAITING VEHICLE AT TOLL GATE AND NO. OF TOLL GATE

Service Time / Ave. Waiting Vehicle at Toll Gate / No. of toll gate	6 sec		8 sec		10 sec		14 sec		18 sec		20 sec	
	1.0	3.0	1.0	3.0	1.0	3.0	1.0	3.0	1.0	3.0	1.0	3.0
1	300	450	230	340	180	270	130	190	100	150	90	140
2	850	1,040	640	780	510	620	360	440	280	350	250	310
3	1,420	1,630	1,070	1,230	850	980	610	700	480	550	430	490
4	2,000	2,230	1,500	1,670	1,200	1,340	860	960	670	740	600	670
5	2,590	2,830	1,940	2,120	1,550	1,700	1,110	1,210	860	940	780	850
6	3,180	3,430	2,380	2,570	1,910	2,060	1,360	1,470	1,060	1,140	950	1,030
7	3,770	4,020	2,830	3,020	2,260	2,410	1,620	1,720	1,260	1,340	1,130	1,210
8	4,360	4,630	3,270	3,470	2,620	2,780	1,870	1,980	1,450	1,540	1,310	1,390
9	4,960	5,220	3,720	3,920	2,980	3,130	2,130	2,240	1,650	1,740	1,490	1,570
10	5,560	5,820	4,170	4,370	3,330	3,490	2,380	2,490	1,850	1,940	1,670	1,750
11	6,150	6,420	4,610	4,820	3,690	3,850	2,640	2,750	2,050	2,140	1,850	1,930
12	6,740	7,020	5,050	5,270	4,040	4,210	2,890	3,010	2,250	2,340	2,020	2,110
13	7,340	7,620	5,510	5,720	4,400	4,570	3,150	3,270	2,450	2,540	2,200	2,290
14	7,940	8,220	5,954	6,170	4,760	4,930	3,400	3,520	2,650	2,740	2,380	2,470
15	8,530	8,820	6,400	6,620	5,120	5,290	3,660	3,780	2,840	2,940	2,560	2,650

Source: NEXCO EAST Highway Design Manual, 2005

(2) Toll Booth Layout

FIGURE 10.4-22 shows the toll booth layout for this project. Toll booth will be constructed beside the traffic control center.

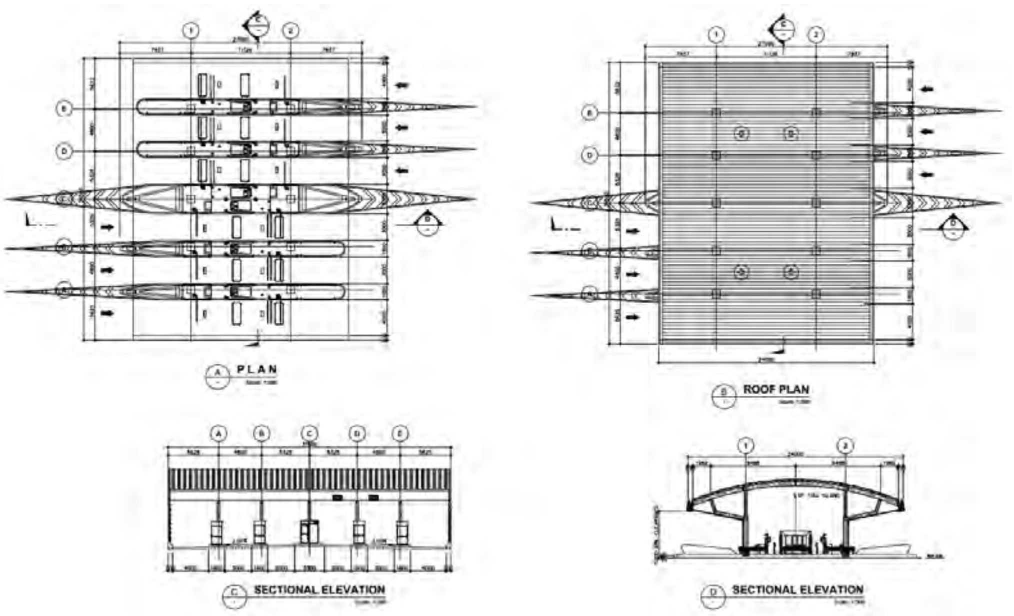


FIGURE 10.4-22 LAYOUT OF TOLL BOOTH

10.5 STRUCTURAL DESIGN

10.5.1 General

(1) Objective

In order to estimate the preliminary project cost, preliminary designs of structures (including Bridge and Box-culvert) were made followed by the calculation of quantities.

(2) Items Included in the Preliminary Designs

The preliminary design includes the following elements:

- Establishment of planning conditions and design criteria
- Establishment of cross sections
- Preliminary designs of bridges, which consist of bridge planning and determination of required structural sections
- Preparation of general drawings
- Calculation of quantities

(3) Summary of Preliminary Design Results

In order to estimate the preliminary project cost, preliminary designs of structures (including Bridge and Box-culvert) were made followed by the calculation of quantities.

TABLE 10.5-1 SUMMARY OF PRELIMINARY BRIDGE DESIGN RESULTS

No.	Section	Location (Sta.)	Number of Bridges (Bypass Road)					Number of Overpass Bridges
			Sum total of Bridges	RCDG	PSCG	PC-Box	St-Truss	
1	Section-I	0+0 to 11+700	10	0	9	1	0	2
2	Section-II	11+700 to 28+800	14	0	14	0	0	4
3	Section-III	28+800 to 44+570	20	0	20	1	0	6
4	Total	---	45	0	43	2	0	12

RCDG: Concrete I-girder, PSCG: Prestressed concrete I-girder,
PC-Box: Prestressed concrete box girder, St-Truss: Steel Truss

Source: JICA Study Team

TABLE 10.5-2 SUMMARY OF PRELIMINARY CULVERT DESIGN RESULTS

No.	Section	Location (Sta.)	Number of Culvert (Bypass Road)		
			Pipe Culvert for Drainage	Box Culvert for River/Waterway	Box Culvert for Crossing Road
1	Section-I	0+0 to 11+700	19	16	0
2	Section-II	11+700 to 28+800	39	16	3
3	Section-III	28+800 to 44+570	24	8	2
4	Total	---	82	40	5

Source: JICA Study Team

10.5.2 Planning Condition and Design Criteria

(1) Crossing Road and Water way

1) Crossing Road

In accordance with the alignment design, the crossing conditions related to the bridge planning were identified.

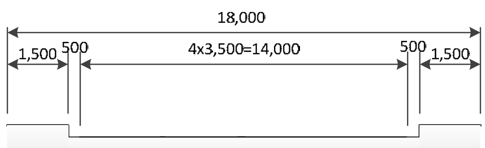
Table 10.5-3 shows the crossing condition and **Table 10.5-4** shows the cross sectional configuration of crossing road.

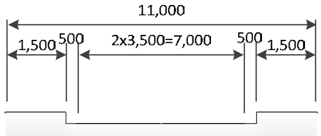
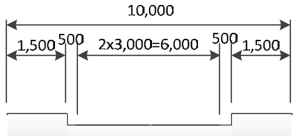
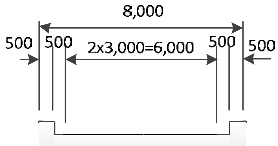
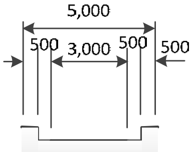
TABLE 10.5-3 LIST OF CROSSING ROAD (EXCEPT CROSSING AT GRADE)

No.	Section	Station	Crossing Road	Road Category		Skew Angles (deg.)	Type of Crossing
				Road Width (m)	Vertical Clearance (m)		
1	II	12+127	Davao-Bukidnon Rd.	18.0	5.2	85	Underpass
2	II	18+824	Barangay Rd.	5.0	4.0	90	Overpass
3	II	22+315	Barangay Rd.	5.0	4.0	90	Underpass
4	II	23+421	Barangay Rd.	5.0	4.0	65	Underpass
5	II	23+826	Mandug Rd.	8.0	4.9	90	Underpass
6	II	24+700	Subdivision Rd.	5.0	4.0	65	Overpass
7	II	25+470	Cabantian Rd.	10.0	4.9	90	Overpass
8	II	27+360	Barangay Rd.	5.0	4.0	90	Overpass
9	III	32+190	Barangay Rd.	5.0	4.0	85	Overpass
10	III	32+989	Acacia- Ilang Rd.	5.0	4.9	70	Overpass
11	III	33+465	Barangay Rd.	5.0	4.0	50	Overpass
12	III	33+965	Barangay Rd.	5.0	4.0	90	Overpass
13	III	34+390	Barangay Rd.	5.0	4.0	85	Overpass
14	III	38+425	Barangay Rd.	5.0	4.0	70	Overpass
15	III	39+355	Barangay Rd.	5.0	4.0	72	Underpass
16	III	44+097	Barangay Rd.	5.0	4.0	90	Underpass

Source: JICA Study Team

TABLE 10.5-4 CROSS SECTIONAL CONFIGURATION OF CROSSING ROAD

No.	Road Category	Road Width (m)	Cross Sectional Configuration	Vertical Clearance (m)
1	Davao-Bukidnon Road	18.0m		5.2m (4.9+0.3m)

No.	Road Category	Road Width (m)	Cross Sectional Configuration	Vertical Clearance (m)
2	National Road/ Provincial Road need not be widened	10.0m		5.2m (4.9+0.3m)
3	Municipality Road	10.0m		5.2m (4.9+0.3m)
4	Farm Road/Private Road/ Barangay Road (2-lane)	8.0m		4.0m (3.8+0.2m)
5	Farm Road/Private Road/ Barangay Road (1-lane)	5.0m		4.0m (3.8+0.2m)

2) Crossing River and Waterway

In accordance with the alignment design, the crossing conditions related to the bridge planning were identified. **Table 10.5.2-3** shows the crossing condition and **Table 10.5.2-4** and **10.5.2-5** shows the typical condition and allowance of free board.

TABLE 10.5-5 LIST OF CROSSING RIVER AND WATERWAY

No.	Section	Station	River Name	Discharge Volume (50years, m^3/s)	Require Free Board (m)
1	I	0+451	Macaring Creek	88.86	0.6
2	I	0+984	Creek 3	56.17	0.6
3	I	1+963	Creek 5	231.24	0.8
4	I	2+574	Bayabas Creek	643.93	1.0
5	I	2+804	Tributary of Bayabas Creek	176.47	0.6
6	I	5+130	Lubogan River	1,682.20	1.0
7	I	6+127	Lipadas River	984.67	0.8
8	I	10+764	Aclihan Creek	111.80	0.6
9	I	11+587	Talomo River Tributary	111.80	0.6
10	I	12+342	Talomo River-	2,390.07	1.2
11	II	17+753	Creek 22	69.08	0.6
12	II	18+580	Malogbok Creek	411.58	0.8
13	II	18+901	Balaag Creek (Matina)	352.52	0.8
14	II	22+953	Davao River	4,650.75	1.2
15	II	27+563	Panacan River	175.03	0.6
16	III	32+541	Communal River	199.24	0.6
17	III	40+235	Tagurot-Bunawan	859.82	1.0
18	III	41+531	Lacanon River	888.42	1.0
19	III	42+770	Creek 42	177.60	0.6
20	III	44+328	Maduao River	2,086.62	1.2

Source: JICA Study Team

TABLE 10.5-6 TYPICAL CONDITION OF CROSSING WATER WAY

Category of water way	Crossing condition	Structure
River	Discharge Volume (50years) <80m^3/s	RCBC with freeboard
	Discharge Volume (50years) >80m^3/s	Bridge with freeboard
	Existing Water Way Width >10m	Bridge with freeboard
Irrigation Canal	Keep the same or more cross section of existing canal	Varies with freeboard

Source: JICA Study Team

TABLE 10.5-7 FREEBOARD ALLOWANCE

No.	Design Discharge Q (m^3/s)	Freeboard (m)
1	Less than 200	0.6
2	200 to less than 500	0.8
3	500 to less than 2,000	1.0
4	2,000 to less than 5,000	1.2
5	5,000 to less than 10,000	1.5
6	More than 10,000	2.0

Source: JICA Study Team

10.5.3 Geometric Design

(1) Typical Cross Section

Typical cross sections employed in the Study are shown in **Figure 10.5.3-1**.

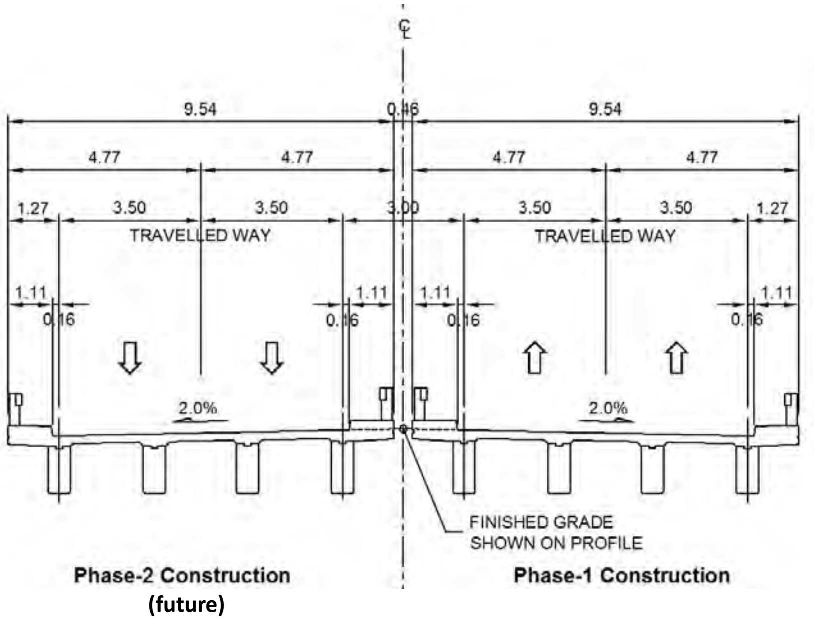
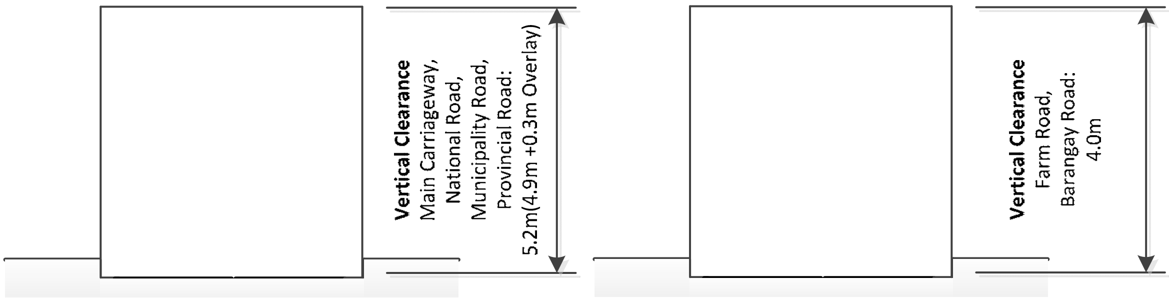


FIGURE 10.5-1 TYPICAL CROSS SECTION FOR BRIDGE

(2) Vertical Clearance

The vertical clearance of the main carriageway and crossing road shall be 4.0m (3.8m + overlay 0.2m) to 5.2m (4.9m + overlay 0.3m).



a) Main Carriageway and High priority crossing road

b) others

FIGURE 10.5-2 VERTICAL CLEARANCE

(3) Horizontal Clearance and Embedded Depth

The pier columns or walls for grade separation structures shall generally be located at a minimum of 9.0m from the edges of the through traffic lanes. Where the practical limits of structure cost, type of structure, volume and design speed of through traffic, span arrangement, skew and terrain make the 9.0m offset impractical, the pier or wall maybe placed closer than 9.0m and protected by the use of guardrail or other barrier devices. The guardrail or other devices shall be independently supported with the roadway face at least 0.60m from the face of pier or abutment.

The face of the guardrail or other device shall be at least 0.60m outside the normal shoulder line. Footings shall be embedded into the ground at least 1.0m from ground surface to the top of footing, and at least 2.0m from the river bed in the river. The effect of buoyancy on the structure shall be verified.

When using a spread footing type, bottom of footings shall be embedded at least 0.5m from the support layer. When using a pile type, bottom of pile shall be embedded at least 1.0 times diameter from the support layer.

10.5.4 Preliminary Design of Bridge Structures

(1) List of Bridges

Table 10.5-8 listed up the number of bridges for preliminary design.

TABLE 10.5-8 LIST OF BRIDGES

PKG	No.	Beginning Sta.	End Sta.	Bridge Length (m)	Nos. of Span	Girder Type	Angle (deg.)	Span Arrangement (m)	Type of Foundation	Apply BH. No.	Crossing Object
I	I-1	0 + 430	0 + 470	40	2	PSCG	90	40	C.I.P pile(φ1200,L=10m)	BH1	
	I-2	0 + 940	1 + 28	88	3	PSCG	90	24 + 40 + 24	C.I.P pile(φ1200,L=10m)		
	I-3	1 + 860	2 + 60	200	5	PSCG	90	40 + 40 + 40 + 40 + 40	C.I.P pile(φ1200,L=10m)	BH2	
	I-4	2 + 505	2 + 635	130	4	PSCG	90	30 + 40 + 30 + 30	C.I.P pile(φ1200,L=10m)	BH3	Bayabas Creak
	I-5	2 + 725	2 + 865	140	4	PSCG	90	30 + 40 + 40 + 30	C.I.P pile(φ1200,L=10m)		
	I-6	3 + 196	3 + 304	108	4	PSCG	90	24 + 30 + 30 + 24	C.I.P pile(φ1200,L=10m)	BH4	
	I-7	4 + 960	5 + 100	140	2	PC-Box	90	70 + 70	C.I.P pile(φ1200,L=10m)	BH5	Lubogan River
	I-8	5 + 100	5 + 260	160	4	PSCG	90	40 + 40 + 40 + 40	Spread F.		Bato River
	I-9	6 + 27	6 + 227	200	5	PSCG	90	40 + 40 + 40 + 40 + 40	C.I.P pile(φ1200,L=10m)	BH6	Lipadas River
	I-10	11 + 570	11 + 610	40	1	PSCG	90	40	C.I.P pile(φ1200,L=10m)	BH8	
II	II-1	12 + 113	12 + 208	95	3	PSCG	90	30 + 35 + 30	C.I.P pile(φ1200,L=10m)	BH8	Davao-Bukdnon Rd.
	II-2	12 + 310	12 + 430	120	3	PSCG	90	40 + 40 + 40	C.I.P pile(φ1200,L=10m)		Talomo River
	II-3	14 + 900	14 + 940	40	1	PSCG	90	40	C.I.P pile(φ1200,L=10m)	BH9	
	II-4	16 + 311	16 + 405	94	3	PSCG	90	24 + 35 + 35	C.I.P pile(φ1200,L=10m)	BH10	
	II-5	16 + 982	17 + 172	190	5	PSCG	90	35 + 40 + 40 + 40 + 35	C.I.P pile(φ1200,L=10m)		
	II-6	17 + 684	17 + 822	138	5	PSCG	90	24 + 30 + 30 + 30 + 24	C.I.P pile(φ1200,L=10m)		
	II-7	18 + 429	18 + 724	295	8	PSCG	90	5 x 40 + 35 + 30 + 30	C.I.P pile(φ1200,L=10m)	BH11	Malogbok Creak
	II-8	18 + 837	18 + 961	124	4	PSCG	90	24 + 40 + 30 + 30	C.I.P pile(φ1200,L=10m)		Matina River
	II-9	22 + 840	23 + 40	200	5	PSCG	90	40 + 40 + 40 + 40 + 40	C.I.P pile(φ1200,L=20m)	BH13	Davao River
	II-10	25 + 60	25 + 270	210	6	PSCG	90	40 + 40 + 40 + 30 + 30 + 30	C.I.P pile(φ1200,L=10m)	BH15	
	II-11	26 + 57	26 + 137	80	2	PSCG	70	40 + 40	C.I.P pile(φ1200,L=10m)		
	II-12	26 + 477	26 + 537	60	2	PSCG	90	30 + 30	C.I.P pile(φ1200,L=10m)		
	II-13	27 + 510	27 + 630	120	3	PSCG	90	40 + 40 + 40	C.I.P pile(φ1200,L=10m)		
	II-14	27 + 865	27 + 905	40	1	PSCG	90	40	C.I.P pile(φ1200,L=10m)		
III	III-1	28 + 938	29 + 168	230	7	PSCG	90	30 + 30 + 35 + 40 + 35 + 30 + 30	C.I.P pile(φ1200,L=10m)	BH16	
	III-2	29 + 195	29 + 250	55	2	PSCG	90	25 + 30	C.I.P pile(φ1200,L=10m)		
	III-3	30 + 50	30 + 144	94	3	PSCG	90	35 + 35 + 24	C.I.P pile(φ1200,L=10m)		
	III-4	30 + 702	30 + 867	165	5	PSCG	90	30 + 35 + 40 + 30 + 30	C.I.P pile(φ1200,L=10m)		
	III-5	31 + 161	31 + 401	240	6	PSCG	90	40 + 40 + 40 + 40 + 40 + 40	C.I.P pile(φ1200,L=12m)	BH17	
	III-6	31 + 512	31 + 687	175	5	PSCG	90	35 + 35 + 35 + 35 + 35	C.I.P pile(φ1200,L=12m)		
	III-7	31 + 828	31 + 918	90	3	PSCG	90	30 + 30 + 30	C.I.P pile(φ1200,L=12m)		
	III-8	32 + 75	32 + 110	35	1	PSCG	90	35	C.I.P pile(φ1200,L=12m)		
	III-9	32 + 386	32 + 666	280	7	PC-Box	90	35 + 60 + 60 + 35 + 30 + 30 + 30	C.I.P pile(φ1200,L=12m)		
	III-10	33 + 579	33 + 657	78	3	PSCG	90	24 + 30 + 24	C.I.P pile(φ1200,L=12m)		
	III-11	33 + 784	33 + 862	78	3	PSCG	90	24 + 30 + 24	C.I.P pile(φ1200,L=12m)		
	III-12	34 + 617	34 + 641	24	1	RCDG	90	24	C.I.P pile(φ1200,L=12m)		
	III-13	34 + 862	34 + 902	40	1	PSCG	90	40	C.I.P pile(φ1200,L=12m)		
	III-14	34 + 968	35 + 48	80	2	PSCG	90	40 + 40	C.I.P pile(φ1200,L=12m)		
	III-15	35 + 355	35 + 390	35	1	PSCG	90	35	C.I.P pile(φ1200,L=12m)		
	III-16	35 + 455	35 + 495	40	1	PSCG	90	40	C.I.P pile(φ1200,L=12m)		
	III-17	36 + 378	36 + 488	110	3	PSCG	90	40 + 40 + 30	C.I.P pile(φ1200,L=12m)		
	III-18	40 + 215	40 + 255	40	1	PSDG	90	40	C.I.P pile(φ1200,L=35m)	BH18	
	III-19	41 + 490	41 + 580	90	3	PSCG	90	30 + 30 + 30	C.I.P pile(φ1200,L=40m)	BH19	Lacanon River
	III-20	42 + 760	42 + 800	40	1	PSCG	90	40	C.I.P pile(φ1200,L=60m)	BH20	
	III-21	44 + 278	44 + 378	100	3	PSCG	90	30 + 40 + 30	C.I.P pile(φ1200,L=60m)		Maduao River

Source: JICA Study Team

(2) Superstructure

The following bridge types shall be adopted depending on the span length, economy and site condition.

Figure 10.5-3 shows the recommended type of superstructure depending on the different span length in the Philippines.

In this study, the commonly used type of superstructure are RCDG, PSCG and special bridge type is choose such as PC box girder and Steel Truss.

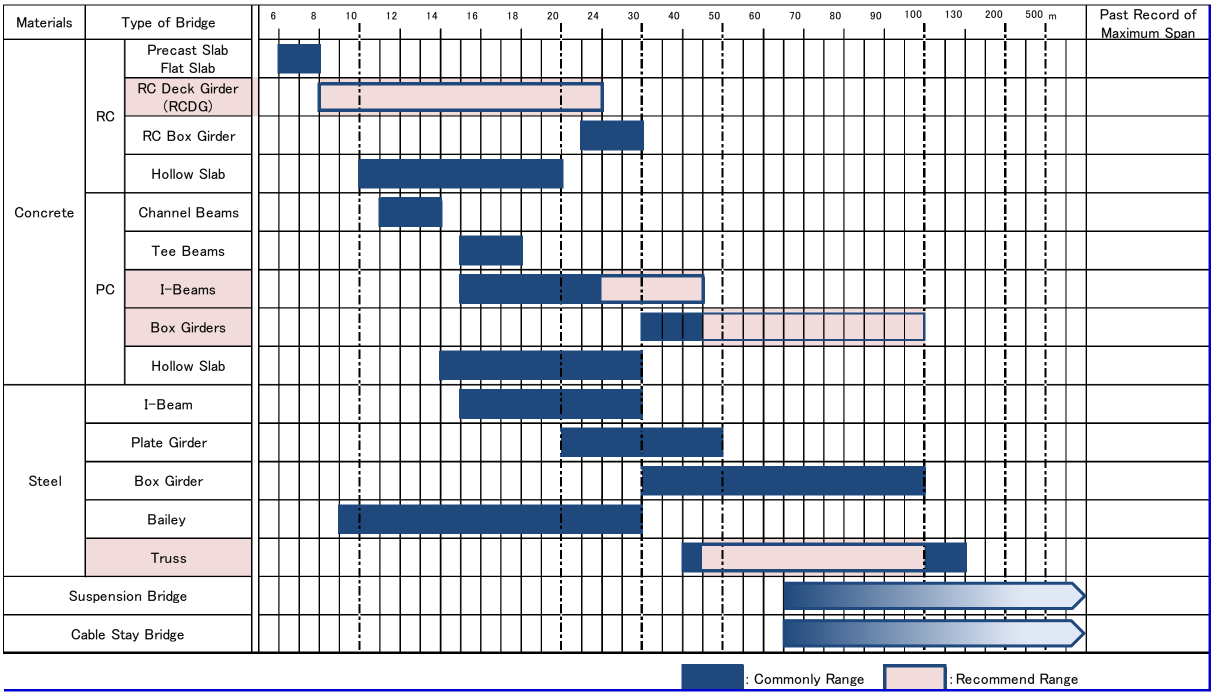


FIGURE 10.5-3 RECOMMENDED SUPERSTRUCTURE TYPE AT EACH SPAN LENGTH

(3) Substructure

The following type of pier shall be adopted in accordance to the site conditions and restrictions.

a) RC column with pier-head type pier.
b) RC hammerhead type pier.

Pile bent type shall not be allowed for improvement of seismic performance.

(4) Foundation

In accordance to the result of the sub-surface soil investigation, constraints factors during construction and others if any, the following types of foundation shall be selected;

a) Spread footing type
b) Cast in place concrete pile (1.2m diameter of piles will be adopted).

Driven pile type shall not be allowed for improvement of seismic performance.

Considering the effect of scour by the flow of river, the selected arrangement of pier type of foundation is the cast in place concrete pile.

(5) Span Arrangement

1) Bridge Length

In case the bridge is located on the deep river valleys and in mountainous areas, it is determined economically, including the many factors such as the stability of the ground, the effect of excavation, slope restoration and road construction. Therefore, it is necessary to locate the most appropriate abutment arrangement.

The following location of abutment shall be adopted in accordance to the site conditions.

a) Maximum height of abutment is 15.0m
b) Especially when abutment is located on a slope, as shown in **Figure 10.5-4.** Distance of toe footing to ground surface of horizontal direction (S: Space of horizontal) shall be keep more than footing length (B).

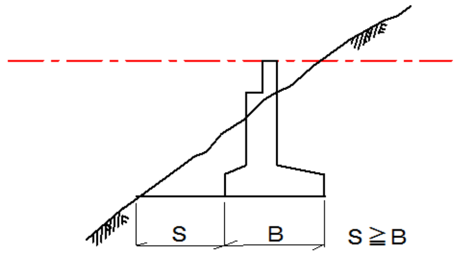


FIGURE 10.5-4 SPACE OF HORIZONTAL ON THE SLOPE ABUTMENT

2) Span Arrangement

There are 3 type bridges that will be utilize in this Study, such as Bridge for Road, Bridge for River/Waterway and Viaduct.

(a) Bridge for Road

Span arrangement of bridge for road shall utilize **Section 10.5.3** geometric design and basically these bridges are arranged as single span.

Especially, through the Davao-Bukidnon Road (No. I-10) is not only keep to existing road width but also keep the ROW (30m) and it is arranged 3 span bridge for advance to the seismic performance

(b) Bridge for River/Waterway

Span arrangement of bridge for river/waterway shall utilize **Section 10.5.3** geometric design. Basically, pier is not arranged in the river flow.

Span arrangement of major river bridge features is utilized.

- **[Sta. 4+960 – 5+260] Bridge of through the Lubogan River (No. I-7,I-8)**

Lubogan river width is approximately 50m. Based on the study result, best of girder type and span arrangement is 2-span PC box girder (70+70m, I-7) and 5-span PSCG (AASHTO girder type, 4@40m, I-8).Based on the geotechnical survey result, foundation type is spread footing. But PC box girder is near water flow, therefore Bridge I-7 cast-in-place pile (1.2m diameter) is selected.

- **[Sta. 12+290 – 12+375] Bridge of through the Talomo River (No. I-12)**

Talomo River width is approximately 30m. Based on the location of abutment, bridge length is 85m. Therefore, girder type and span arrangement is 3-span PSCG (AASHTO girder type, 40+40+40m). Based on geotechnical survey result, foundation type is Cast-in-place pile (1.2m diameter).

- **[Sta. 22+840 – 23+40] Bridge of through the Davao River (No. II-9)**

Davao River width is approximately 120m. This bridge is located from about 200m downstream from the existing “Waan Bridge” which has 100m bridge length (4-span x 25m, PSCG). On the other hand, both dike behaved erosion shown **Photo 10.5-1**. Therefore abutment disengaged dike from 1-span and bridge length is 200m. Based on the study result, the best appropriate girder type and span arrangement is 5-span PSCG (AASHTO girder type V, 5@40m). Based on geotechnical survey result, the foundation type is cast-in-place pile (1.2m diameter).

PHOTO 10.5-1 EROSION BEAVER ON DAVAO RIVER DIKE

- **[Sta. 41+490 – 41+580, 44+278 – 44+378] Bridge of through the Lacanon River (No. III-19) and Bridge of through the Maduao River (No. III-21)**

Lacanon River and Maduao river width is approximately 20m and 30m respectively. However, based on the hydraulic analysis during flood, these rivers overflow. Therefore, these bridges need an opening length enough than the current river bank state. These bridges would be arranged as 3-span bridges (30+30+30m and 30+40+30m respectively). Based on the geotechnical survey result, the foundation type is cast-in-place pile (1.2m diameter).

- **[Sta. 40+215 – 40+255, 42+760 – 42+800] Bridge through the Small River (No. III-18,20)**

These small river width is approximately less than 20m. According to the hydraulic analysis, during flood, this river may overflow. Therefore, this bridge need an opening length enough than the current state river bank. This bridge is arrange as a single-span bridge (40m). Based on the geotechnical survey result, the foundation type d is cast-in-place pile (1.2m diameter).

(c) Viaduct

"Viaduct" shall be defined that low effect by crossing object then long length bridge by deep valley.

Span arrangement of viaduct shall utilize **section 10.5.3** geometric design. And basically, pier is not arranged in the river flow. Span arrangement of major viaduct features are the following;

- **[Sta. 18+425 – 18+720] Bridge through the Malogbok Creek (No. II-7)**

Malogbok Creek is about more than 30m in depth. Bridge length is 295m best girder type and span arrangement is 8-span PSCG (AASHTO girder type V, 5@ 40+35+30+30m). Based on geotechnical survey result, foundation type is cast-in-place pile (1.2m diameter).

- **[Sta. 32+385 – Sta. 32+695] Bridge through deep creek (No. III-9)**

This Creek is about than 30m in depth . Bridge length is 310m., best girder type and span arrangement is 8-span PSCG (AASHTO girder type V, 5@ 40+35+30+30m). Based on geotechnical survey result, foundation type is cast-in-place pile (1.2m diameter).

(6) Study on alternative Bridge Types

To make a decision about the girder type and span arrangement of major bridges, an alternative study attention is focused on the following items;

- Economically (include construction cost, maintenance cost)
- Structurally (include commonality, seismic adequacy,)
- Constructability (include period, scale of temporary facility<equipment, access road>)
- Maintainability (include particularity of inspection and repair work)

To perform a comparative study about the bridges as shown below.

- Section I, I-7,I-8 (main feature; Long length river bridge)
- Section II, II-7 (main feature; Long length viaduct<deep valley>)
- Section II, II-9 (main feature; through the Davao river)
- Section III III-9 (main feature; Long length viaduct<deep valley>)

Bridge for comparison and results are as follows;

TABLE 10.5-9 RESULT OF COMPARISON STUDY SECTION-I BRIDGE I-7, 8

Alternative No.		Alternative-1	Alternative-2
Girder Type		PC-Box Girder + PSCG	PC-Box Girder + PSCG
Span arrangement		(70+70)+(20+30x4+20)=140+160m	(70+70)+(40x4)=140+160m
Structurally	Commonality	PC-Box girder is not commonality but had few bridges in Philippine. PSCG is most of commonality in Philippine. (★★)	PC-Box girder is not commonality but had few bridges in Philippine. PSCG is most of commonality in Philippine. (★★)
	Seismic adequacy	Continuous girder has excellent seismic performance. (★★★)	Continuous girder has excellent seismic performance. (★★★)
Constructability	Period	For 5-piers, the construction period is longer than the Alternative-2 (★★)	For 3-piers, the construction period is shorter than the Alternative-1 (★★★)
	Scale of temporary facility	For 5-piers, length of temporary road for construction is longer than the Alternative-2 (★★)	For 3-piers, length of temporary road for construction is shorter than the Alternative-1 (★★★)
Maintainability	Particularity of inspection and Repair works	PC box girder needs special inspection and repair works. But PSCG doesn't need special technic. (★★)	PC box girder needs special inspection and repair works. But PSCG doesn't need special technic. (★★)
Economically	Construction cost	PhP – 189,975,000 (1.16)	PhP – 163,496,000 (1.00)
Decision		---	Recommend

TABLE 10.5-10 RESULT OF COMPARISON STUDY SECTION-II BRIDGE II-7

Alternative No.		Alternative-1	Alternative-2	Alternative-3
Girder Type		PSCG	PSCG	PC-Box girder
Span arrangement		30x9+25=295m	40x5+35+30x2=295m	40+75x3+40=305m
Structurally	Commonality	PSCG is most of commonality in Philippine. (★★★)	PSCG is most of commonality in Philippine. (★★★)	PC-Box girder had few bridges in Philippine. (★★)
	Seismic adequacy	Continuous girder has excellent seismic performance. (★★★)	Continuous girder has excellent seismic performance. (★★★)	Continuous girder has excellent seismic performance. (★★★)
Constructability	Period	For 9-piers, the construction period is longer than the Alternative-2. (★★)	For 7-piers, the construction period is shorter than the Alternative-1. (★★★)	For cantilever method, the construction period is longer than PSCG. (★★)
	Scale of temporary facility	For 9-piers, length of temporary road for construction is longest. (★★)	For 7-piers, length of temporary road for construction is middle. (★★)	For 9-piers, length of temporary road for construction is shortest. (★★★)
Maintainability	Particularity of inspection and Repair works	For PSCG, Inspection and Repair works is easy. (★★★)	For PSCG, Inspection and Repair works is easy. (★★★)	For PC-Box girder, Inspection and Repair works is need to special technic. (★★)
Economically	Construction cost	PhP – 216,271,000 (1.20)	PhP – 180,012,000 (1.00)	PhP – 191,459,000 (1.06)
Decision		---	Recommend	---

TABLE 10.5-11 RESULT OF COMPARISON STUDY SECTION-II BRIDGE II-9

Alternative No.		Alternative-1	Alternative-2	Alternative-3
Girder Type		PSCG	PSCG	PC-Box girder
Span arrangement		25+30x5+25=200m	40x5=200m	40+60x2+40=200m
Structurally	Commonality	PSCG is most of commonality in Philippine. (★★★)	PSCG is most of commonality in Philippine. (★★★)	PC-Box girder had few bridges in Philippine. (★★)
	Seismic adequacy	Continuous girder has excellent seismic performance. (★★★)	Continuous girder has excellent seismic performance. (★★★)	Continuous girder has excellent seismic performance. (★★★)
Constructability	Period	For 6-piers, the construction period is longer than the Alternative-2. (★★)	For 4-piers, the construction period is shorter than the Alternative-1. (★★★)	For cantilever method, the construction period is longer than PSCG. (★★)
	Scale of temporary facility	For launching election, it needs special equipment. (★★)	For launching election, it needs special equipment. (★★)	For cantilever method, it doesn't need special equipment. (★★★)
Maintainability	Particularity of inspection and Repair works	For PSCG, Inspection and Repair works is easy. (★★★)	For PSCG, Inspection and Repair works is easy. (★★★)	For PC-Box girder, Inspection and Repair works is need to special technic. (★★)
Economically	Construction cost	PhP – 168,643,000 (1.04)	PhP – 162,266,000 (1.00)	PhP – 170,940,000 (1.05)
Decision		---	Recommend	---

TABLE 10.5-12 RESULT OF COMPARISON STUDY SECTION-III BRIDGE III-9

Alternative No.		Alternative-1	Alternative-2
Girder Type		PC-Box Girder + PSCG	PC-Box Girder
Span arrangement		(35+60x2+35)+(30x3)=190+90m	35+60x4+35=310m
Structurally	Commonality	PC-Box girder is not commonality but had few bridges in Philippine. PSCG is most of commonality in Philippine. (★★)	PC-Box girder is not commonality but had few bridges in Philippine. (★★)
	Seismic adequacy	Continuous girder has excellent seismic performance. (★★★)	Continuous girder has excellent seismic performance. (★★★)
Constructability	Period	Pier is many but cantilever method is shorten. Therefore, the construction period is shorter than Alternative-2 (★★★)	Pier is shorten but cantilever method is longer. Therefore, the construction period is longer than Alternative-2 (★★)
	Scale of temporary facility	For 6-piers, length of temporary road for construction is longer than the Alternative-2 (★★)	For 5-piers, length of temporary road for construction is shorter than the Alternative-1 (★★★)
Maintainability	Particularity of inspection and Repair works	PC box girder needs special inspection and repair works. But PSCG doesn't need special technic. (★★)	PC box girder needs special inspection and repair works. (★★)
Economically	Construction cost	PhP – 233,866,000 (1.00)	PhP – 251,387,000 (1.07)
Decision		Recommend	---

(7) Overpass Bridges

1) List of Overpass Bridges

TABLE 10.5-13 LIST OF OVERPASS BRIDGES

PKG	No.	Station			Crossing Object	Nos. of Span	Girder Type	Angle (deg.)	Span Arrangement (m)		
I	IO-1	3	+	820	Brgy. Rd.	2	PSCG	90	25	+	25
	IO-2	9	+	80	Brgy. Rd.	2	PSCG	90	25	+	25
II	IIO-1	18	+	820	Brgy. Rd.	2	PSCG	80	25	+	20
	IIO-2	24	+	700	Subdivision Rd. (UC)	2	PSCG	90	25	+	30
	IIO-3	25	+	470	Cabantian Rd.	2	PSCG	65	25	+	25
	IIO-4	27	+	360	Brgy. Rd.	2	RCDG	90	20	+	20
III	IIIO-1	32	+	190	Brgy. Rd.	2	PSCG	90	30	+	25
	IIIO-2	32	+	990	Acacia-Ilang Rd.	2	PSCG	75	25	+	25
	IIIO-3	33	+	465	Brgy. Rd.	2	PSCG	90	25	+	20
	IIIO-4	33	+	965	Private Rd.	2	RCDG	90	20	+	20
	IIIO-5	34	+	390	Private Rd.	2	RCDG	90	20	+	20
	IIIO-6	38	+	425	National Rd.	2	PSCG	80	25	+	20

2) Span arrangement and girder type

Span arrangement of bridges for river/waterway will follow **Section 10.5.3** geometric design. Basically, pier is arranged in median strip. Therefore overpass bridges have 2-span bridges.

When crossing barangay road or private road, the rearrangement skew angle will be 90 degrees.

The type of girder depends on span length. Span length that is less than 20m will utilize a RCDG and that is more than 20m will utilize a PSCG.

10.5.5 Preliminary Design of Culvert Structures

(1) List of Culvert

Table 10.5-14 list up the RCBC for roads and **Table 10.5-15** list up the RCBC and RCPC for rivers and waterways.

TABLE 10.5-14 LIST OF RCBC FOR ROAD

PKG	Station			Crossing Object	Type	Dimensions		
						Nos. of Barrel	Inne r Section	
							Width (m)	Height (m)
II	22	+	315	Barangay Road	RCBC	1	4.0	4.0
II	23	+	421	Barangay Road	RCBC	1	6.0	3.5
II	23	+	826	Mandug Rd.	RCBC	1	6.0	5.0
III	39	+	354	Barangay Road	RCBC	1	5.0	5.0
III	44	+	97	Barangay Road	RCBC	1	5.0	5.0

Source: JICA Study Team

TABLE 10.5-15 LIST OF RCBC AND RCPC FOR RIVER AND WATERWAY - SECTION 1

No.	PKG	Station			Crossing Object	Type	Dimensions		
							Nos. of Barrel	Inner Section	
								Width or Diameter (m)	Height (m)
1	I	0	+	15	Waterway	RCBC	1	1.20	0.90
2	I	0	+	83	Waterway near Lipadas River1	RCBC	3	3.00	2.50
3	I	1	+	182		rcpc	1	1.07	
4	I	1	+	350		rcpc	1	1.07	
5	I	1	+	450		rcpc	1	1.07	
6	I	1	+	549	Creek4	RCBC	1	5.00	5.00
7	I	1	+	753		rcpc	1	0.91	
8	I	1	+	784		rcpc	1	1.07	
9	I	3	+	600		rcpc	1	1.07	
10	I	2	+	297		rcpc	1	0.91	
11	I	2	+	968		RCBC	1	3.00	3.00
12	I	3	+	978	Creek10	RCBC	1	2.00	2.00
13	I	7	+	490	Creek11	RCBC	1	2.40	2.40
14	I	4	+	535		rcpc	1	1.07	
15	I	6	+	804		rcpc	1	1.52	
16	I	7	+	221		rcpc	1	1.07	
17	I	7	+	423	Waterway14	RCBC	1	4.00	4.00
18	I	8	+	61		RCBC	1	1.20	1.20
19	I	8	+	304		rcpc	1	1.07	
20	I	8	+	474		rcpc	1	1.52	
21	I	8	+	674		RCBC	1	3.00	3.00
22	I	8	+	910	Waterway15	RCBC	3	3.00	2.10
23	I	10	+	320		RCBC	3	2.00	1.80
24	I	9	+	562	Waterway16	RCBC	3	3.00	2.50
25	I	9	+	796		rcpc	1	0.91	
26	I	9	+	950		RCBC	1	0.90	0.90
27	I	9	+	961		RCBC	1	1.20	0.90
28	I	11	+	270		rcpc	1	0.91	
29	I	10	+	409		rcpc	1	1.07	
30	I	10	+	610		rcpc	1	1.07	
31	I	10	+	765	Aclihan Creek-R8	RCBC	3	3.00	3.00
32	I	10	+	896		rcpc	1	1.07	
33	I	11	+	159		rcpc	1	1.07	
34	I	11	+	387		RCBC	1	5.00	2.50
35	I	11	+	656		rcpc	1	1.52	

Source: JICA Study Team

TABLE 10.5-16 LIST OF RCBC AND RCPC FOR RIVER AND WATERWAY – SECTION 2

No.	PKG	Station			Crossing Object	Type	Dimensions		
							Nos. of Barrel	Inner Section	
								Width or Diameter (m)	Height (m)
36	II	11	+	792		rcpc	1	0.91	
37	II	11	+	883		rcpc	1	0.91	
38	II	11	+	925		rcpc	1	0.91	
39	II	12	+	73		rcpc	3	1.52	
40	II	13	+	403		rcpc	1	1.52	
41	II	13	+	650		rcpc	1	1.52	
42	II	13	+	858		RCBC	1	1.20	0.90
43	II	13	+	892		rcpc	1	0.91	
44	II	13	+	973		rcpc	1	1.52	
45	II	14	+	367	Creek18 & 19	RCBC	3	3.00	3.00
46	II	14	+	641	Waterway	RCBC	1	4.00	3.00
47	II	14	+	679		RCBC	1	4.00	3.00
48	II	15	+	363	Waterway	RCBC	3	3.00	3.00
49	II	15	+	732		rcpc	1	1.07	
50	II	15	+	958		rcpc	1	1.52	
51	II	16	+	69		rcpc	1	1.07	
52	II	16	+	418		rcpc	1	1.07	
53	II	16	+	585		rcpc	1	1.52	
54	II	17	+	607		rcpc	1	0.91	
55	II	17	+	860		rcpc	1	1.52	
56	II	18	+	21		rcpc	1	1.52	
57	II	18	+	83		rcpc	1	1.52	
58	II	21	+	397		rcpc	1	0.91	
59	II	21	+	454		rcpc	1	0.90	
60	II	21	+	539		rcpc	1	1.52	
61	II	21	+	650		rcpc	1	0.91	
62	II	21	+	819		rcpc	1	1.07	
63	II	21	+	913		rcpc	1	1.52	
64	II	22	+	188		rcpc	1	1.52	
65	II	22	+	385		rcpc	1	1.52	
66	II	22	+	483		RCBC	1	5.00	3.00
67	II	22	+	605		rcpc	1	1.52	
68	II	22	+	629		RCBC	1	5.00	5.00
69	II	22	+	792		RCBC	1	3.00	2.50
70	II	23	+	364		RCBC	1	5.00	3.00
71	II	23	+	439		rcpc	3	1.52	
72	II	23	+	529		rcpc	1	1.07	
73	II	23	+	721		rcpc	1	0.91	
74	II	23	+	937		rcpc	1	0.91	
75	II	24	+	453	Waterway	RCBC	3	2.40	2.10
76	II	24	+	815		rcpc	1	1.52	
77	II	25	+	836		rcpc	1	1.07	
78	II	25	+	411		rcpc	1	1.52	
79	II	25	+	832		rcpc	1	1.52	
80	II	25	+	899		rcpc	1	1.52	
81	II	25	+	971		rcpc	1	1.07	
82	II	26	+	186		rcpc	1	1.52	
83	II	26	+	520	Waterway29	RCBC	1	3.00	2.75
84	II	26	+	950		RCBC	1	1.20	0.90
85	II	27	+	276		rcpc	1	1.52	
86	II	27	+	401		rcpc	1	0.91	
87	II	28	+	517		RCBC	1	3.00	2.50
88	II	28	+	616		RCBC	1	2.00	2.00
89	II	28	+	705		RCBC	1	1.20	0.60
90	II	28	+	721		RCBC	1	1.20	0.60

Source: JICA Study Team

TABLE 10.5-17 LIST OF RCBC AND RCPC FOR RIVER AND WATERWAY – SECTION 3

No.	PKG	Station			Crossing Object	Type	Dimensions		
							Nos. of Barrel	Inner Section	
								Width or Diameter (m)	Height (m)
91	III	29	+	400		rcpc	1	1.52	
92	III	29	+	464	Waterway33	RCBC	1	5.00	3.00
93	III	29	+	516		rcpc	1	1.52	
94	III	29	+	599		rcpc	1	1.52	
95	III	29	+	819	Waterway	RCBC	1	3.00	3.00
96	III	30	+	207		rcpc	1	0.91	
97	III	33	+	272		rcpc	1	1.07	
98	III	33	+	728		rcpc	1	1.52	
99	III	36	+	804		rcpc	1	0.91	
100	III	37	+	120		rcpc	1	1.52	
101	III	39	+	420		rcpc	3	1.52	
102	III	39	+	700		rcpc	1	0.91	
103	III	39	+	779		rcpc	1	1.52	
104	III	40	+	840		rcpc	3	1.07	
105	III	41	+	0		rcpc	1	0.91	
106	III	41	+	347		rcpc	1	1.07	
107	III	41	+	675		rcpc	1	0.91	
108	III	41	+	918		rcpc	1	0.91	
109	III	42	+	50		rcpc	1	1.52	
110	III	42	+	188		RCBC	1	5.00	2.50
111	III	42	+	341		rcpc	1	1.52	
112	III	42	+	443		rcpc	1	1.52	
113	III	42	+	570		rcpc	1	1.52	
114	III	42	+	667		rcpc	1	1.52	
115	III	43	+	70		rcpc	1	1.52	
116	III	43	+	444		rcpc	1	0.91	
117	III	43	+	535		rcpc	1	1.07	
118	III	43	+	656		RCBC	1	1.50	1.25
119	III	43	+	835		RCBC	3	1.50	1.50
120	III	43	+	943		RCBC	1	3.00	2.10
121	III	44	+	460		RCBC	3	1.50	1.00
122	III	44	+	553		RCBC	2	1.50	1.50

Source: JICA Study Team

(2) Type of Culvert

1) Pipe Culvert

Pipe culvert is utilized for valley of stream after rain and irrigation canal. The dimension of pipe culvert is at least 910m diameter.

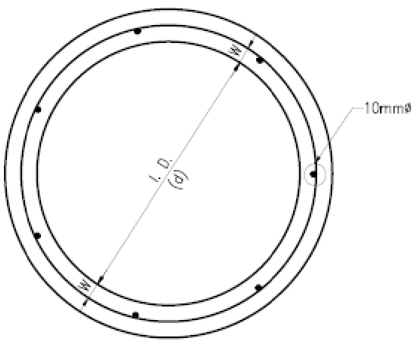


FIGURE 10.5-5 TYPICAL CROSS SECTION AT PIPE CULVERTBOX CULVERT FOR CROSSING ROAD

Box culvert is applied for less than 6m width of road crossing such as barangay road and farm road.

2) Box Culvert for Crossing River and Waterways

Box culvert is applied for less than 6m width of road crossing. Portal rigid frame type is applied less than 12m width and discharge volume more than $80m^3/s$.

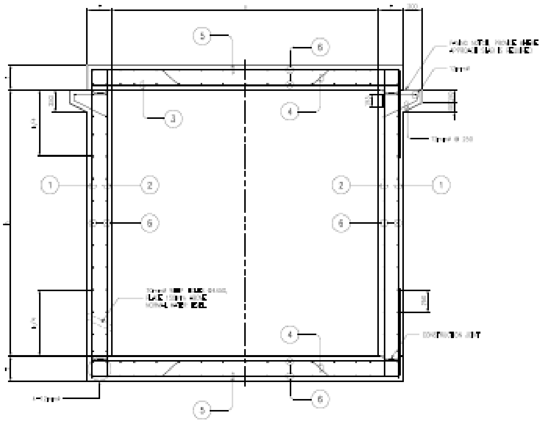


FIGURE 10.5-6 TYPICAL CROSS SECTION OF RCBC SINGLE BARREL

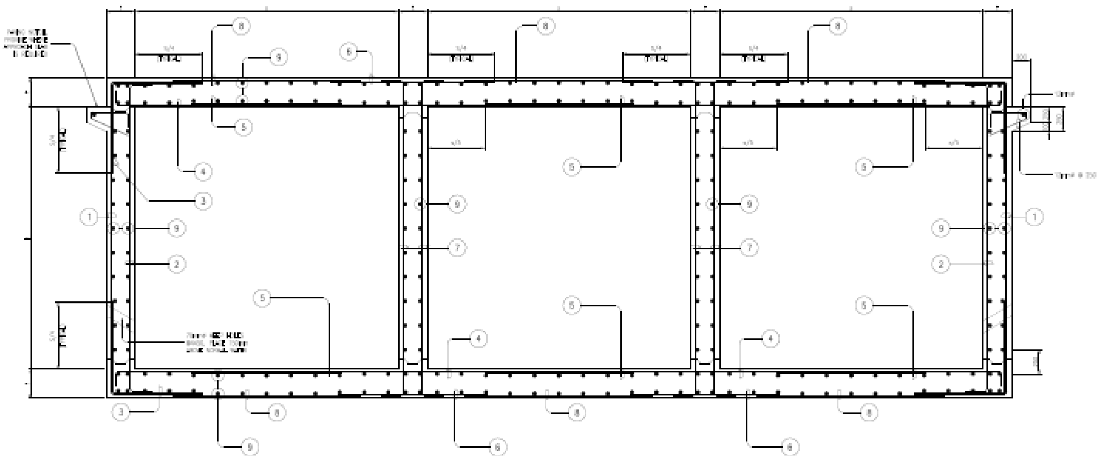


FIGURE 10.5-7 TYPICAL CROSS SECTION OF RCBC TRIPLE BARREL

10.5.6 Effects of seismically unstable ground

(1) General

The effects of the unstable ground shall be taken into account in the verification of seismic performance of a bridge when the ground is expected to be in an unstable state during an earthquake. Unstable ground is defined as an extremely soft soil layer in seismic design, or a sandy layer affecting the bridge due to the liquefaction and lateral spreading.

In addition to the verification of the seismic performance of a bridge with conditions indicated in soft soil layer and/or sandy layer above, the case in which the ground is assumed to be stable shall also be considered in order to ensure the seismic performance of the bridge for both stable and unstable ground conditions.

Verification of seismic performance, assessment of soil liquefaction, reduction of geotechnical parameters and verification of foundations for liquefaction-induced lateral spreading is refer to LRFD Bridge Seismic Design Specifications (DPWH guide specifications, 2013, 1st edition.

1) **Assessment of Extremely Soft Soil Layer in Seismic Design**

For a clayey layer or a silt layer located within three meters from the ground surface, and having a compressive strength of 20kPa (kN/mm^2) or less obtained from an unconfined compression test or an in-situ test, the layer shall be regarded as an extremely soft layer in seismic design.

2) **Assessment of Soil Liquefaction and Countermeasure**

(a) Sandy layer requiring liquefaction assessment

For an alluvial sandy layer having all of the following three conditions, liquefaction assessment shall be conducted in accordance with the provisions specified below and shown **Figure 10.5.6-1**, since liquefaction may affect the bridge performance during an earthquake.

a. Saturated soil layer with depth less than 20m below the ground surface and having ground water level higher than 10m below the ground surface.
b. Soil layer containing a fine contend (FC) of 35% or less, or soil layer having plasticity index, Ip less than 15, even if FC is larger than 35%.
c. Soil layer having a mean particle size (D_{50}) of less than 10mm and a particle size at 10% passing (D_{10}) (on the grading curve) is less than 1mm.

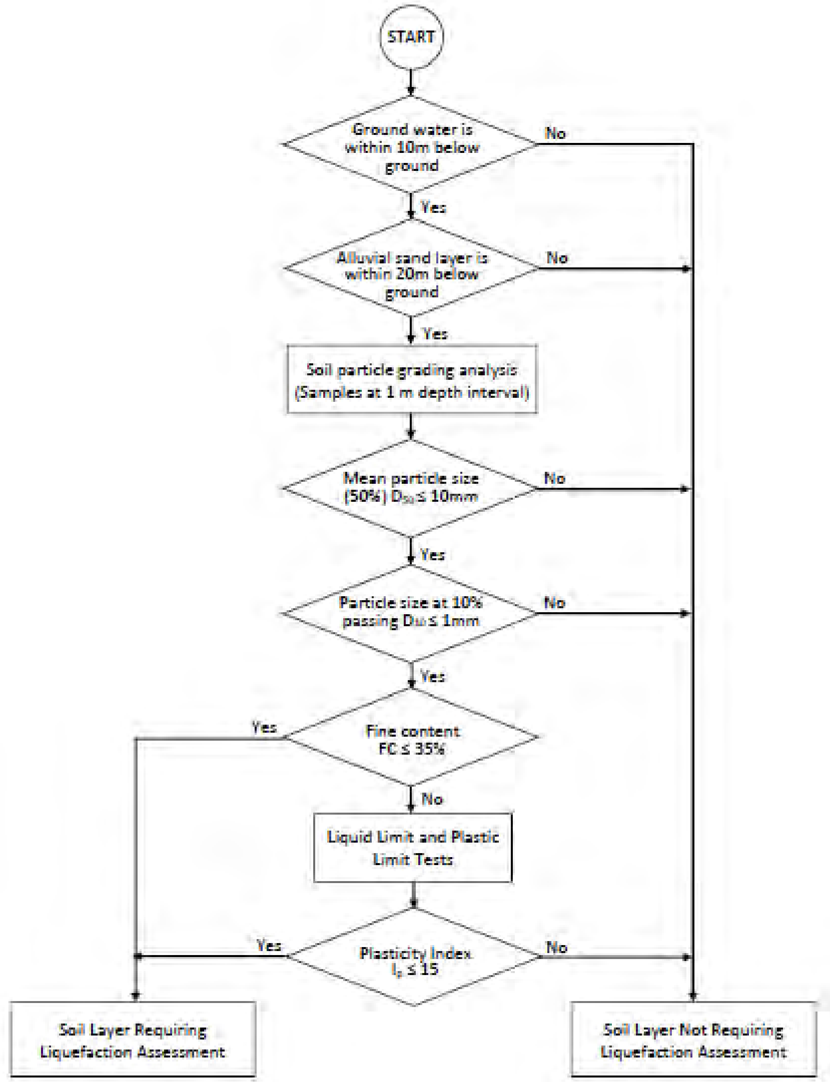


FIGURE 10.5-8 DETERMINATION OF NECESSITY FOR LIQUEFACTION ASSESSMENT OF SOIL LAYER

(b) Reduction of geotechnical parameters

When a soil layer is considered to be an extremely soft layer according to the provisions specified in (2), its geotechnical parameters (shear modulus and strength) shall be assumed to be zero in the seismic design.

For a sandy layer causing liquefaction and affecting the bridge shall be equal to the product of geotechnical parameters obtained without liquefaction and the coefficient D_E in **Table 10.5-18**. For the case when D_E=0, the geotechnical parameters (shear modulus and strength) shall be taken as 0 in seismic design.

The weight of a soil layer with reduced or zero geotechnical parameter in the seismic design shall be assumed to be acting as an overburden.

TABLE 10.5-18 REDUCTION FACTOR D_E FOR GEOTECHNICAL PARAMETERS

Range of F_L	Depth from Present Ground Surface x (m)	Dynamic Shear Strength Ratio, R	
		$R \le 0.3$	$0.3 < R$
		Verification for Level 2 Earthquake Ground Motion	Verification for Level 2 Earthquake Ground Motion
$F_L \le 1/3$	$0 \le x \le 10$	0	1/6
	$10 < x \le 20$	1/3	1/3
$1/3 < F_L \le 2/3$	$0 \le x \le 10$	1/3	2/3
	$10 < x \le 20$	2/3	2/3
$2/3 < F_L \le 1$	$0 \le x \le 10$	2/3	1
	$10 < x \le 20$	1	1

(c) Recommended for liquefaction

According to geotechnical survey, it shall be consider to soil liquefaction to BH-17 to BH-20. When detailed design stage, it shall be more detailed geotechnical test and follow the specification for soil liquefaction.

3) For Lateral Spreading

(a) Ground with possible lateral movement

A ground with both of the following two conditions shall be treated as a ground with possible lateral movement affecting the bridge.

a. Ground within a distance of less than 100m from a water front in a shore area formed by a revetment with an elevation difference of 5m or more between the water bottom and the ground surface behind (see **Figure 10.5.6-2**).
b. Ground with a sandy layer thicker than 5m that is assessed as a liquefiable layer according to the provision in 10.5.6.(3) and is distributed somewhat widely in the area of the water front.

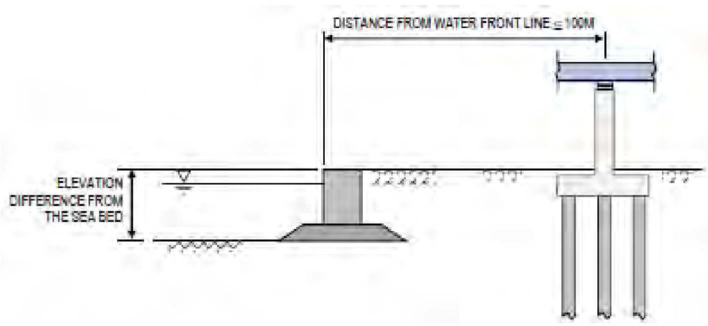


FIGURE 10.5-9 ELEVATION DIFFERENCE FROM THE SEA BED AND DISTANCE FROM THE WATER FRONT LINE

(b) Verification of seismic performance of a bridge for liquefaction-induced lateral spreading

A pier foundation situated on a ground specified in 1) above shall be verified against possible liquefaction-induced lateral spreading. In the verification, lateral movement force specified 3) shall act on the pier foundation. However, the lateral movement force and the inertia force not to be considered simultaneously.

(c) Recommended for Lateral Spreading

According to geotechnical survey, it shall be consider to soil liquefaction to BH-18 to BH-20. When detailed design stage, it shall be more detailed geotechnical test and follow the specification for soil liquefaction.

Remediation objectives include increasing the soils liquefaction resistance through densification, increasing its strength, and/or improving its drainage. The most common remediation measures bellow.

Surcharge - The weight of a surcharge/buttress increases the liquefaction resistance by increasing the effective confining pressures in the foundation.

Drains - Relief of excess pore water pressure to prevent liquefaction. (Wick drains have comparable permeability to sand drains). Primarily gravel drains; sand/wick may supplement gravel drain or relieve existing excess pore water pressure. Permanent dewatering with pumps.

Compaction Piles - Densification by displacement of pile volume and by vibration during driving, increase in lateral effective earth pressure.

Deep soil-cement mixing methods - The in situ injection and mixing of cement into weak soils is becoming more common. Recent applications include liquefaction mitigation and the strengthening of weak cohesive soils adjacent to embankments, levees and bridge abutments.

10.6 PAVEMENT DESIGN

10.6.1 General

This section describes pavement design for the bypass project. The pavement design is based on the following;

1) The results and findings of the subgrade characteristics over which the road is to be built;
2) The traffic load anticipated to traverse the proposed road alignments over the selected design life; and
3) The type of pavement to be adopted based on the technical and economical advantages.

10.6.2 Technical Approach

The design parameters used in the pavement design includes time constraints, traffic, design serviceability loss, reliability, subgrade and material properties for pavement structure design. The following are the major design conditions;

(1) Design Period

10 years
It is assumed that the design life of pavement consummates the 20-year design period before rehabilitation is performed.

(2) Traffic

The structural design of the pavement is based on fatigue loads. Fatigue loading is taken as the cumulative number of passes of an Equivalent Standard Axle Load (ESAL) of 8,300 kgs (18kips) per axle, to which the pavement structure will be subjected throughout its design life.

10.6.3 Recommended Pavement Structures

The recommended pavement structures for the bypass main carriageway is below;

Portland Cement Concrete Pavement (PCCP)		
No.	Thickness	Pavement
1	300 mm	Portland Cement Concrete Pavement
2	300 mm	Crushed Aggregate Base Course

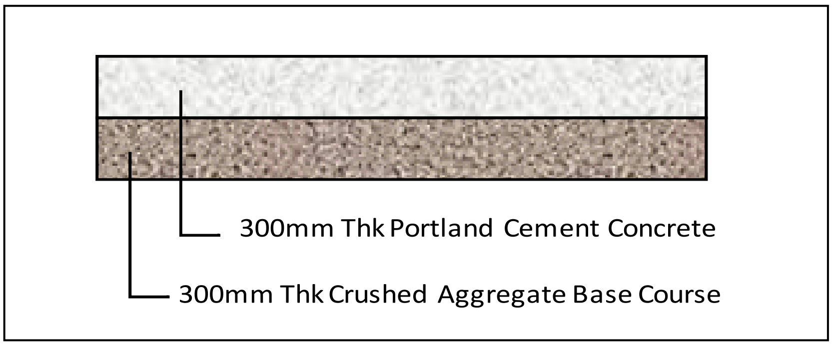


FIGURE 10.6-1 PAVEMENT STRUCTURE OF MAIN CARRIAGEWAY

10.7 DRAINAGE DESIGN

10.7.1 General

The elimination of floods and the protection against Inundation of a roadway / its facilities forms one of the major problems in road design. Adequate flood controls and drainage measures will invariably reduce damage to a roadway and its facilities, thus minimizing maintenance and operational cost and even reconstruction cost as the case may be.

The hydrological conditions / studies concerning the drainage of proposed bypass road are assessed as follows.

10.7.2 Meteorological Conditions

Davao City is outside the typhoon belt and lacks major seasonal variations as shown in **Figure 10.7-1**. The city belongs to Type IV Climate that has mild tropical rainforest climate where rainfall is more or less evenly distributed throughout the year with no dry season as shown in **Figure 10.7-2**.

There is a synoptic observation station of climatic data in and around Davao city, which installed and have been operated by Philippine Atmospheric, Geophysical & Astronomical Services Administration (PAGASA) as shown in **Table 10.7-1** and **Figure 10.7-3**.

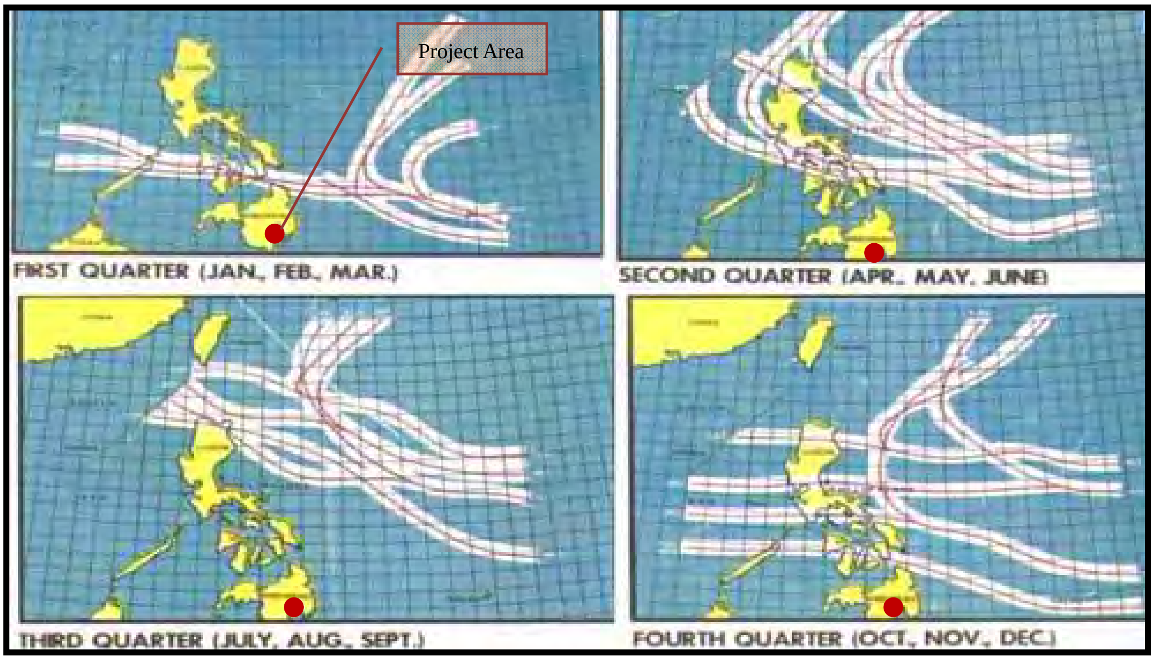


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FIGURE 10.7-1 ANNUAL TRACKS OF TROPICAL CYCLONE

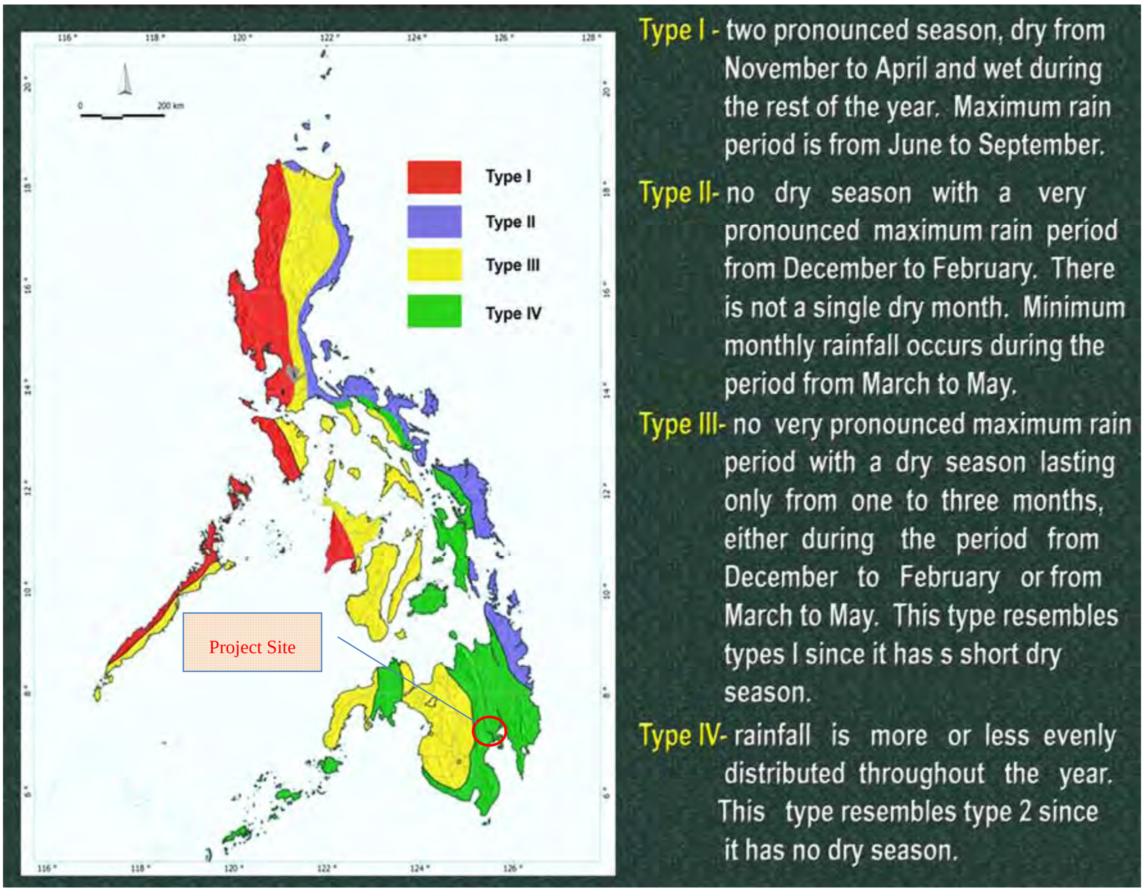

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FIGURE 10.7-2 CLIMATE MAP OF THE PHILIPPINES

TABLE 10.7-1 INVENTORY OF METEOROLOGICAL STATION

Meteorological Station	Code (WMO)	Coordinates		Height (m)	Period of Records				Remarks
		Latitude	Longitude		Temperature	Relative Humidity	Rainfall	Wind	
1. Davao (synoptic station)	98753	07-07'N	125-39' E	18	1951-	1951-	1951-	1951-	

Source: PAGASA

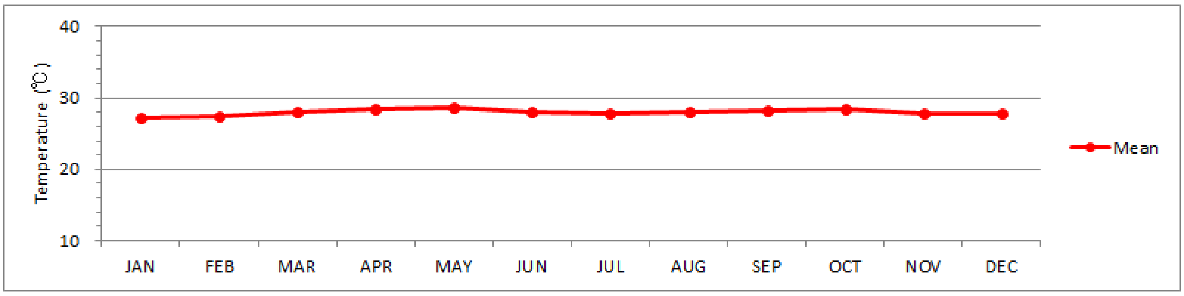
Source: JICA Study Team based on the image of Google earth

FIGURE 10.7-3 LOCATION MAP OF METEOROLOGICAL AND HYDROLOGICAL STATIONS

(1) General weather conditions

1) Temperature

The monthly mean temperature has a range between 28.6℃ and 27.3℃ in Davao city. According to collected data, the mean monthly maximum temperature 29.1℃ (May 2010) and the mean minimum temperature 27.0℃ (January 2011) at Davao city were recorded respectively during the recent 5 years. The monthly mean temperature is substantially constant throughout the year, and its fluctuation range is very small. The daily mean temperature typically varies from 24℃ to 33℃, and is rarely below 23℃ or above 34℃.

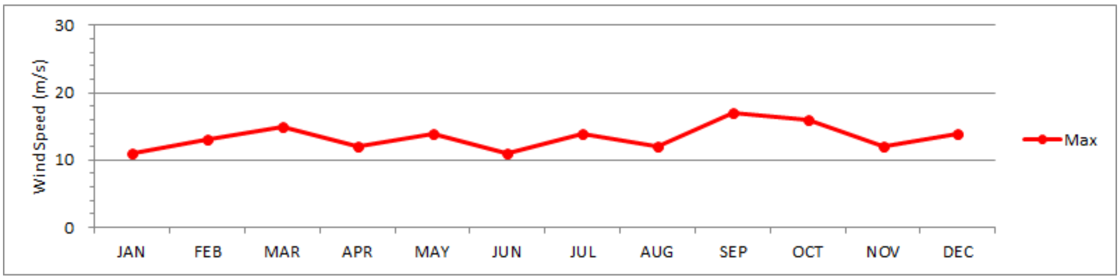


Source: JICA Study Team based on the data from PAGASA

FIGURE 10.7-4 MONTHLY MEAN TEMPERATURE AT DAVAO STATION (2008-2012)

2) Wind Speed and Direction

Over the course of the year, typical wind speeds varies from 0 m/s to 5 m/s, and it rarely exceeds 8 m/s. However, the maximum wind speed was recorded at range between 8 and 17 m/s during months of past 5 years. (The city is outside the typhoon belt.)
The typical wind is mostly the direction of the north (17% of the time) and south (14% of the time).

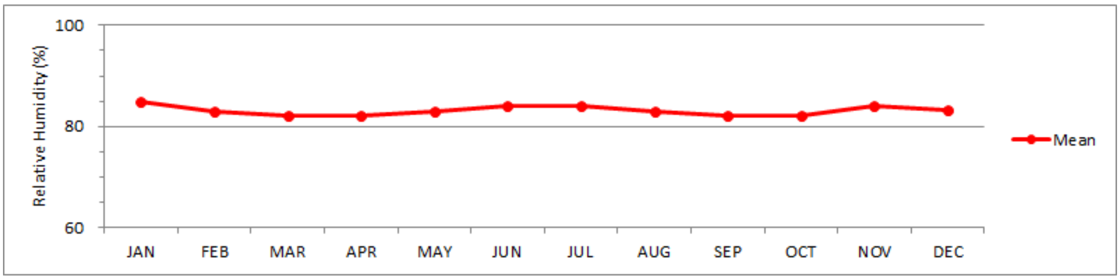


Source: JICA Study Team based on the data from PAGASA

FIGURE 10.7-5 MONTHLY MAXIMUM WIND SPEED AT DAVAO STATION (2008-2012)

3) Relative Humidity

The mean monthly relative humidity in Davao City is ranging between 78% and 86% during months of past 5 years. And the daily mean high / low relative humidity typically ranges from 61% to 95% over the course of the year.



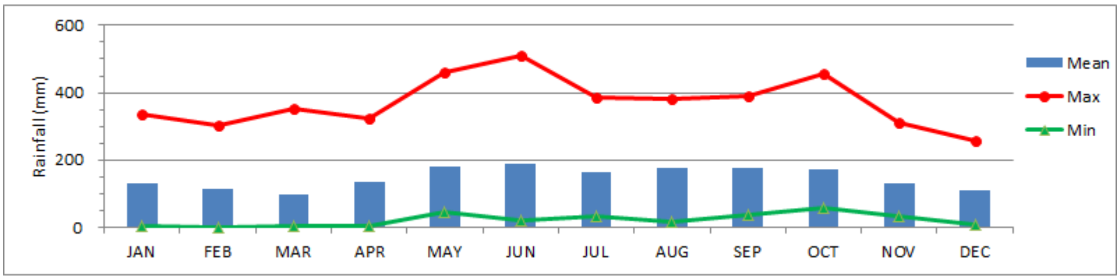
Source: JICA Study Team based on the data from PAGASA

FIGURE 10.7-6 MEAN MONTHLY RELATIVE HUMIDITY AT DAVAO STATION (2008-2012)

(2) Rainfall

1) Annual Rainfall and Seasonal Fluctuation

The monthly mean rainfall of past 52 years is no characteristic seasonal fluctuation, but the precipitation is slightly greater during May to October which the thunderstorms are easy to occur, as shown in **Figure 10.7-7**. However, its fluctuation range (max/min) of each month of past 52 years is relatively big. The monthly mean rainfall for each month varies from 191mm to 98mm, the annual mean rainfall is 1786mm. (1128 - 2358mm).

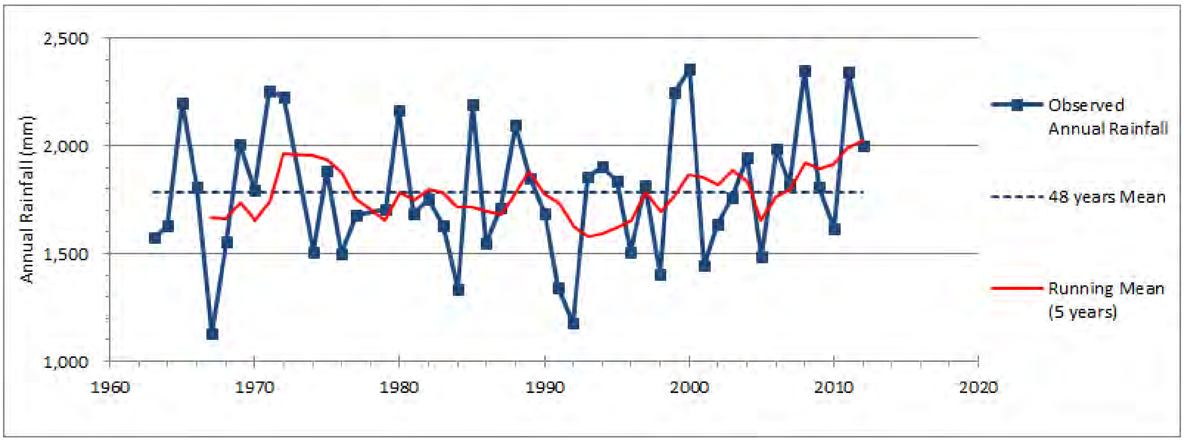


Source: JICA Study Team based on the data from PAGASA

FIGURE 10.7-7 MONTHLY MEAN (MAXIMUM, MINIMUM) RAINFALL AT DAVAO STATION (1961-2012)

2) Long-term Fluctuation of Annual Rainfall

According to the data of 48 years in the past, the annual rainfall varies from 1128mm to 2358mm as shown in **Figure 10.7-8**. (Average is 1786mm.) Also, this Figure is shown the long-term fluctuation of annual rainfall by using 5 year running mean at Davao. The cycle of wet and droughty periods is not clear, but it is indicated that limited rise trend of annual rainfall is going on in recent years.



Source: JICA Study Team based on the data from PAGASA

FIGURE 10.7-8 5-YEAR RUNNING MEAN RAINFALL AT DAVAO (1963-2012)

3) Exceedance Probability and Intensity Curve of Rainfall

The annual maximum daily rainfall data (extreme value) over 50 years or more in Davao meteorological station was collected. The 24 hour rainfalls of 2-100 year probabilities are calculated by using these extreme values of Davao station. On the other hand, the PAGASA had also estimated the probable rainfall each duration time, by using 62 year's records of Davao station. Both results of probability calculation are shown in **Table 10.7-2**.

TABLE 10.7-2 PROBABLE RAINFALL EACH RAINFALL DURATION AT DAVAO STATION

Return Period (Probability) (year, %)		Probable Rainfall each rainfall duration (mm) by PAGASA									Probable Rainfall by JICA study team	Remarks
		0.167	0.333	0.5	1	2	3	6	12	24hr		
		10	20	30	60	120	180	360	720	1440min		
2	50%	19.5	30.0	38.2	53.2	65.2	71.6	80.3	85.8	91.4	96.0	
5	20%	25.1	39.3	51.0	73.2	88.8	96.4	108.7	114.9	121.1	125.4	
10	10%	28.8	45.4	59.4	86.5	104.5	112.8	127.5	134.1	140.7	144.8	
15	6.667%	30.9	48.9	64.2	94.0	113.3	122.1	138.1	145.0	151.8	155.8	
20	5%	32.4	51.3	67.6	99.3	119.5	128.6	145.5	152.6	159.5	163.5	
25	4%	33.5	53.2	70.1	103.3	124.2	133.6	151.2	158.5	165.5	169.4	
50	2%	37.0	59.0	78.1	115.8	138.9	149.0	168.8	176.5	183.9	187.7	
100	1%	40.5	64.7	85.9	128.1	153.5	164.2	186.3	194.4	202.1	205.8	

Note: Probable rainfall by PAGASA was estimated based on past 61 year's record, and values of JICA Study Team are the estimation by past 52 year's record.

Source: PAGASA, JICA Study Team

As a result, the both probable rainfalls in case of 24 hour rainfall are nearly same, and hence, the value of PAGASA will be used in this study. The rainfall intensity calculated from the given probable rainfall is shown in **Table 10.7-3**.

TABLE 10.7-3 RAINFALL INTENSITY EACH RAINFALL DURATION AT DAVAO STATION

Return Period (Probability) (year, %)		Rainfall intensity each rainfall duration (mm/hr) by PAGASA									Remarks
		0.167	0.333	0.5	1	2	3	6	12	24hr	
		10	20	30	60	120	180	360	720	1440min	
2	50%	116.9	90.1	76.4	53.2	32.6	23.9	13.4	7.2	3.8	
5	20%	150.7	117.9	102.0	73.2	44.4	32.1	18.1	9.6	5.0	
10	10%	173.0	136.3	118.9	86.5	52.2	37.6	21.2	11.2	5.9	
15	6.667%	185.6	146.7	128.4	94.0	56.7	40.7	23.0	12.1	6.3	
20	5%	194.5	154.0	135.1	99.3	59.7	42.9	24.2	12.7	6.6	
25	4%	201.3	159.6	140.3	103.3	62.1	44.5	25.2	13.2	6.9	
50	2%	222.2	176.9	156.1	115.8	69.5	49.7	28.1	14.7	7.7	
100	1%	243.0	194.0	171.9	128.1	76.7	54.7	31.0	16.2	8.4	

Source: PAGASA

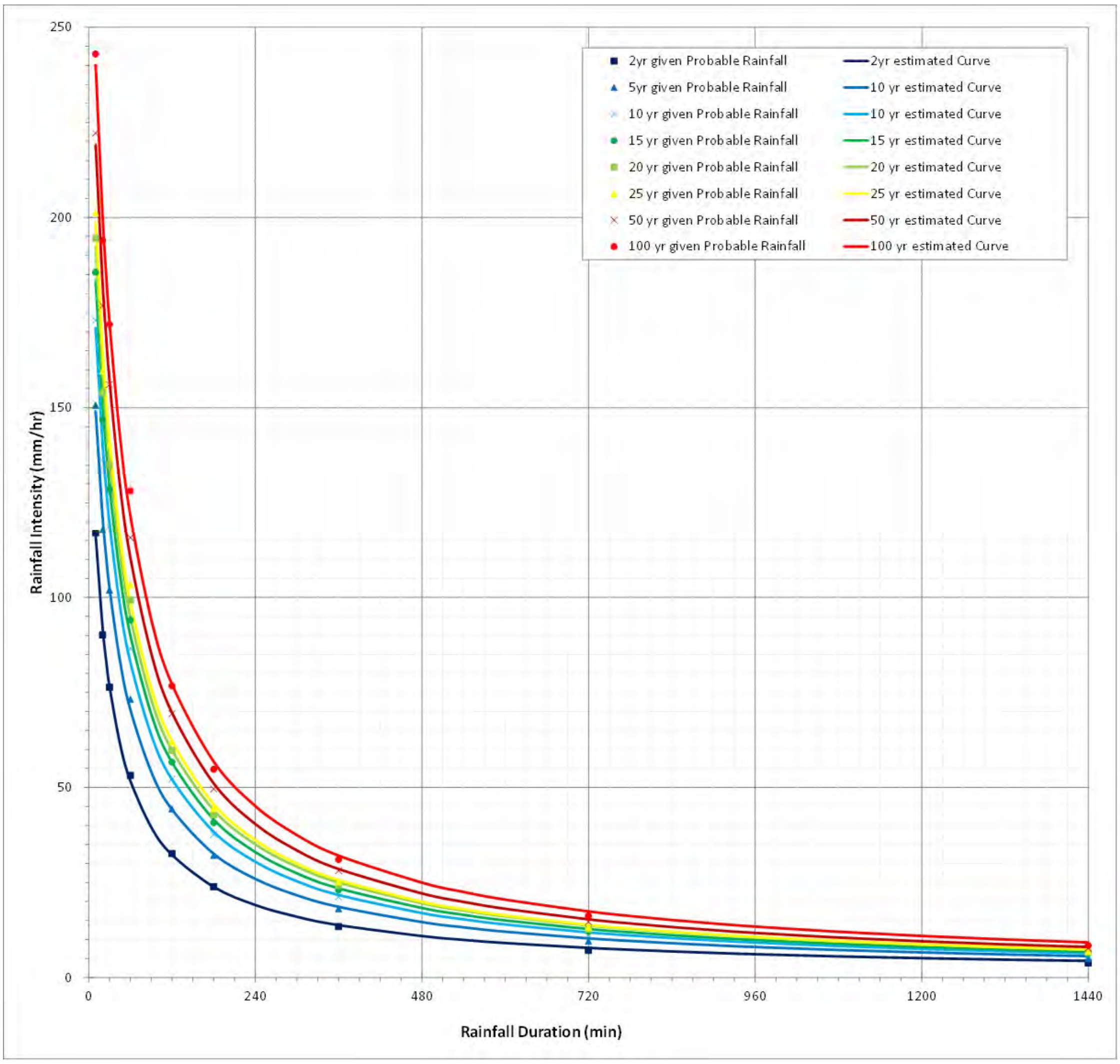
The application for the rainfall intensity formula from the rainfall intensity, are estimated by solver function (least square method) of Microsoft Excel. Although there are many methods for rainfall intensity equation, the equation of Horner type is adopted in accordance with the DPWH's guideline in this Study. The rainfall intensity curve and the parameter of equation are shown in **Table 10.7-4** and **Figure 10.7-9**.

TABLE 10.7-4 COEFFICIENTS FOR RAINFALL INTENSITY FORMULA AND APPLIED PERIODS

Return Period (year, %)		Coefficient of Intensity Curve $I = A / (t + b)^n$			Design Criteria					Remarks
		A	b	n	Ditches and Road Surface	Embank-ment	Pipe Culverts Drainage Pipes	Rivers ($A<40km^2$) Box Culverts	Rivers ($A\geq40km^2$)	
2	50%	2262.7	21.90	0.858	○					
5	20%	3949.3	28.33	0.899						
10	10%	5413.3	32.05	0.924		○				
15	6.667%	6325.7	33.89	0.936			○			
20	5%	6325.8	33.51	0.926						
25	4%	7553.9	35.98	0.951			△	○		
50	2%	9340.3	38.45	0.967				△	○	
100	1%	9340.3	37.59	0.948					△	

Note: "○" shows the design period applied, and "⊿" shows the design period for check.

Source: JICA Study Team based on the data from PAGASA



Source: JICA Study Team based on the data from BRS of DPWH

FIGURE 10.7-9 RAINFALL INTENSITY CURVE AT DAVAO STATION

10.7.3 Hydrological / Hydraulic Conditions

In order to predict the flow rate / water level in flood season, it is necessary to collect and correlate the hydrological and hydraulic conditions of the related rivers surrounding proposed bypass road.

In this study area, there are the past hydrological records of 5 gauge stations (for Davao, Lasang, Talomo, Lipadas and Matina rivers). The gauge station (for observing water level/discharge) is managed by the Bureau of Research and Standards (BRS) of DPWH. Of these stations, the 4 stations has been operating even now, but only Matina station was abolished already. Also, the location of Davao and Lasang stations were respectively changed one time in the past.

Inventory of river gauge stations is shown in **Table 10.7-5**. (Also, the location of them is shown in **Figure 10.7-1**.)

TABLE 10.7-5 INVENTORY OF RIVER GAUGE STATIONS

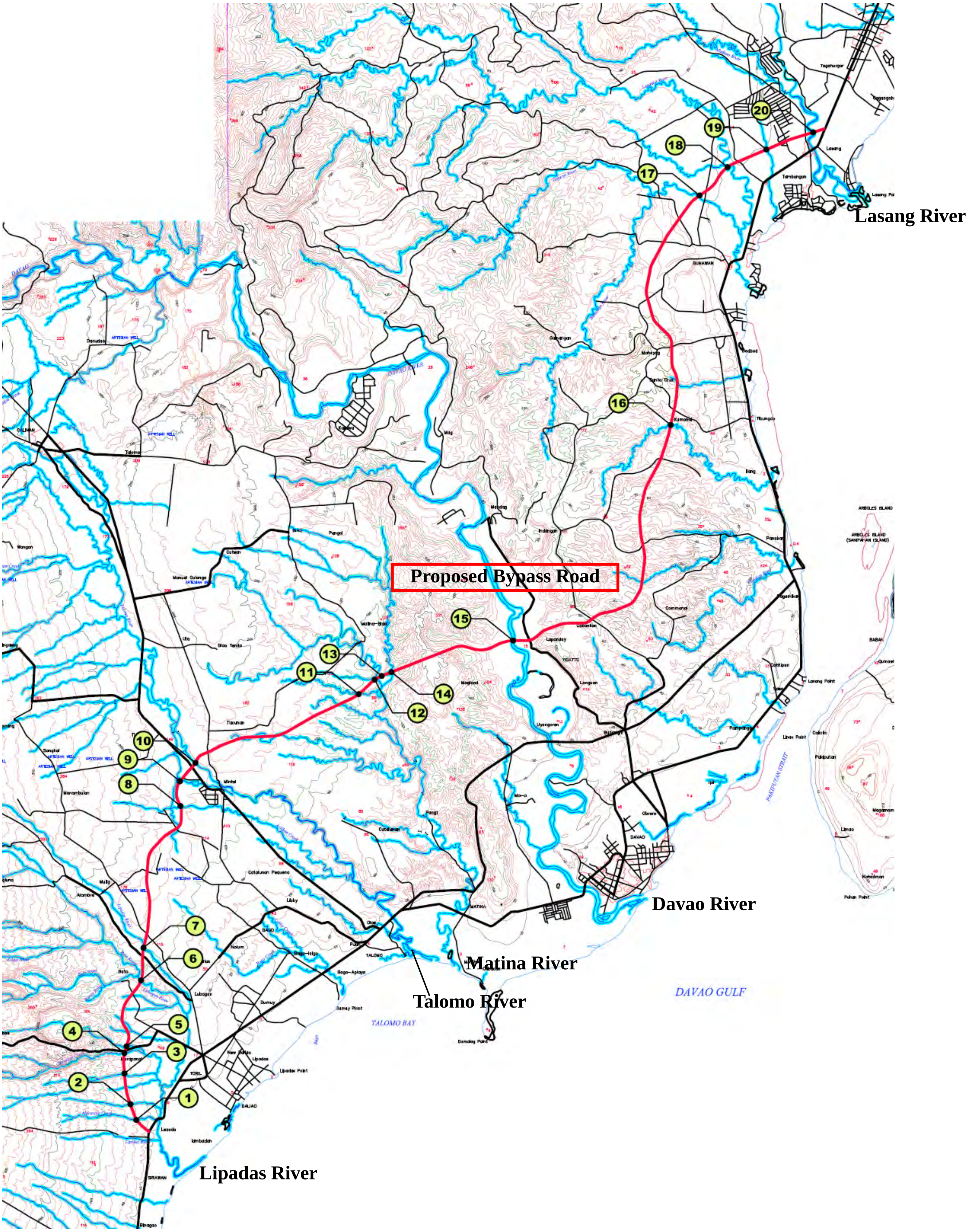
River / Gauging Station	Coordinates		Catchment Area (km2)	Height (m)	Type of Gauge	Period of Record	Water (Tide) level	Discharge	Observed by	Remarks
	Latitude	Longitude								
1. Davao River / Lacson	07-13'-53"	125-26'-32"	1,469	10.502	Staff Gauge	2001-	○	○	BRS	
1. Davao River / Tigatto	07-5'-38"	125-35'-35"	1,683	20	Staff Gauge	1984-1999	○	○	BRS	old station
2. Lasang River / Brgy	7-20'-12"	125-30'-42"	344	15.718	Staff Gauge	2002-	○	○	BRS	
2. Lasang River / Mabuhay	7-19'-28"	125-32'-2"	354	17.155	Staff Gauge	1985-1989	○	○	BRS	old station
3. Talomo River / Angalan II	7-8'-25"	125-28'-40"	165	13.235	Staff Gauge	1986-	○	○	BRS	
4. Lipadas River / Barangay	7-0'-12"	125-29'-4"	149	10	Staff Gauge	1986-	○	○	BRS	
5. Matina River / Pangi	7-7'-16"	125-32'-21"	48	5.89	Staff Gauge	1959-1970	○	○	BRS	old station

Source: BRS of DPWH

(1) Major Rivers and the Characteristics of River Flow

A substantial part of the Davao City is mountainous, characterized by extensive mountain ranges with uneven distribution of plateaus and lowlands. The mountain range at the western boundary extends as far down as South Cotabato and it nestles the Mountain Apo (the highest mountain peak in the Philippines at elevation 3,144 meters). Mountain Apo is considered as semi-active volcano. The large and contiguous lowland areas of the city are coastal plains and valleys extending inland as gently rising valleys. The entire land area of the city is drained by the above 5 rivers towards the Davao Gulf and the largest is Davao River. These rivers and their numerous tributaries are the main natural drainage systems in the area. Davao River originates from Davao del Norte, flows in a southward meandering along the central part of the City.

As rivers with a large catchment basin of the other, there are Lasang, Talomo, Lipadas and Matina Rivers. The location of major rivers in Davao city is shown in **Figure 10.7-10**.



Source: JICA Study Team based on the data from NAMRIA

FIGURE 10.7-10 LOCATION OF MAJOR RIVERS IN DAVAO CITY

1) Characteristics of River Flow

(a) Flow Characteristics of Related Rivers

The discharge-duration curve which is often used in Japan is examined in order to understand the potential surface water characteristics of the river through the year. The flow regime shows the annual flow condition using the daily discharge at each hydrological station, and is indicated by the daily discharge and the number of exceeded days. The annual flow regime shows as follows;

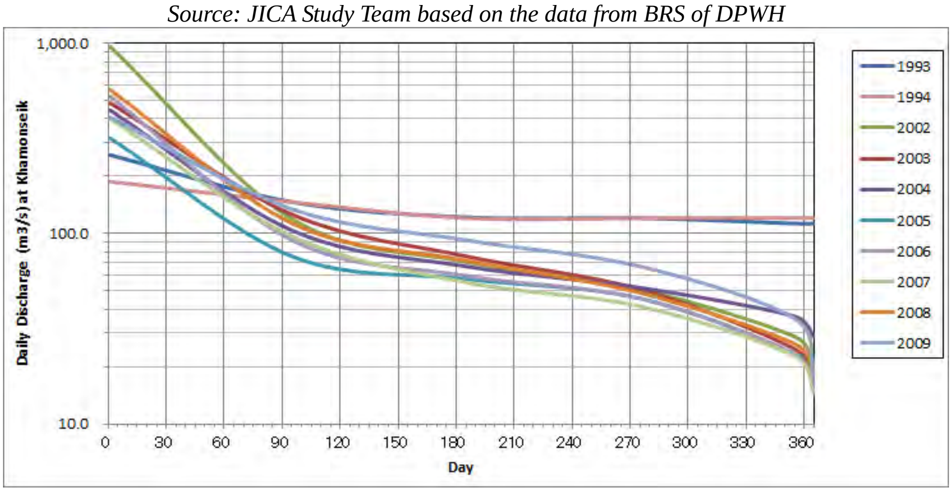
- High Discharge (95th daily discharge from the greatest)
- Normal Discharge (185th daily discharge from the greatest)
- Low Discharge (275th daily discharge from the greatest)
- Drought Discharge (355th daily discharge from the greatest)

The flow regime which was computed at 4 river gauge stations except the Matina River for recent 10 years period, is summarized in **Table 10.7-6 - Table 10.7-9** and **Figure 10.7-11 - Figure 10.7-14** The coefficient of river regime is the ratio of the minimum flow and the maximum flow rate at optional point of the river, and shows the stability of the river flow quantitatively. For example, in the Europe, 18 - Basel of the Rhine River, 4 - Vienna of the Danube river, 34 - the Seine River. In Japan, 930 - the Tone River, 870 - the Kiso River, 5060 - the Yoshino River.) As seeing in these Table and Figure, the coefficient of river regime differs by rivers. Also, the magnitude of coefficient of river regime indicates that the flow fluctuation is large, and if it is large, it indicates that the full year water intake is difficult and the flood damage is easy to occur.

TABLE 10.7-6 FLOW REGIME OF DAVAO RIVER DURING RECENT 10 YEARS

Year	Drainage Area (km^2)	Daily Discharge (m^3/s)							Coefficient of River Regime	Remarks
		Max.	High Dischage	Normal Discharge	Low Discharge	Drought Discharge	Min.	Mean		
			95th day	185th day	275th day	355th day				
1993	1,683	259	147	122	121	113	113	142	2.3	old station
1994	1,683	188	147	121	121	121	121	132	1.6	
2002	1,469	959	120	71	51	29	21	105	46.2	new station
2003	1,469	485	126	76	51	25	17	98	28.5	
2004	1,469	445	104	67	52	37	29	93	15.4	
2005	1,469	317	76	58	46	23	17	67	18.6	
2006	1,469	526	92	60	46	23	16	82	32.9	
2007	1,469	401	97	55	42	23	15	77	27.6	
2008	1,469	569	113	72	49	26	19	99	30.3	
2009	1,469	408	134	92	67	36	18	115	22.5	
Mean	-	456.0	116.0	79.0	64.0	46.0	38.0	101.0	12.0	

Source: JICA Study Team based on the data from BRS of DPWH



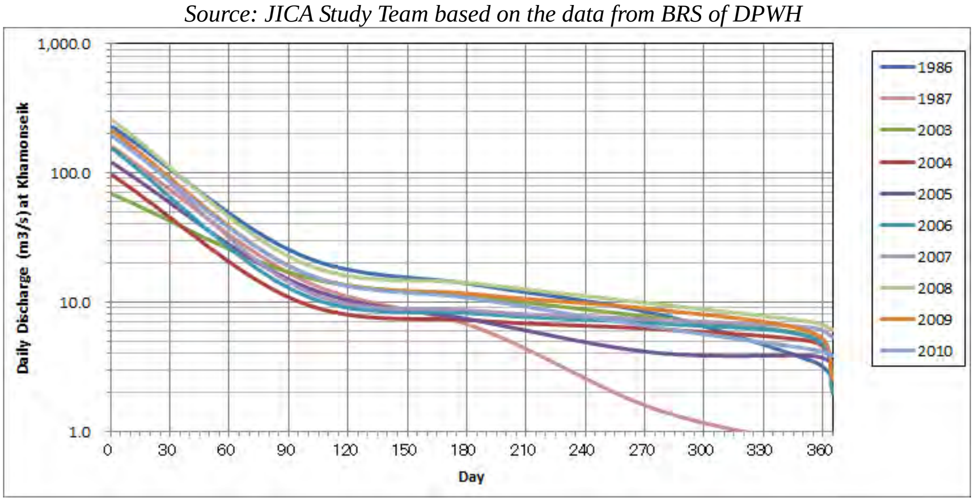
Source: JICA Study Team based on the data from BRS of DPWH

FIGURE 10.7-11 FLOW REGIME OF DAVAO RIVER DURING RECENT 10 YEARS

TABLE 10.7-7 FLOW REGIME OF LASANG RIVER DURING RECENT 10 YEARS

Year	Drainage Area (km^2)	Daily Discharge (m^3/s)							Coefficient of River Regime	Remarks
		Max.	High Dischage	Normal Discharge	Low Discharge	Drought Discharge	Min.	Mean		
			95th day	185th day	275th day	355th day				
1986	354	227	23	14	8	3	3	19	86.2	old station
1987	354	158	15	6	1	1	1	13	198.0	2 month- missing
2003	344	68	16	11	8	5	3	14	24.7	new station
2004	344	96	10	7	6	5	3	11	28.1	
2005	344	119	14	7	4	4	3	13	35.1	
2006	344	153	12	8	7	5	2	15	77.9	
2007	344	216	13	9	7	6	5	16	40.1	
2008	344	254	21	14	10	7	6	20	41.6	
2009	344	210	18	12	9	6	3	19	83.8	
2010	344	192	18	11	6	4	4	16	49.7	
Mean	-	169.0	16.0	10.0	7.0	5.0	3.0	16.0	56.3	

Source: JICA Study Team based on the data from BRS of DPWH



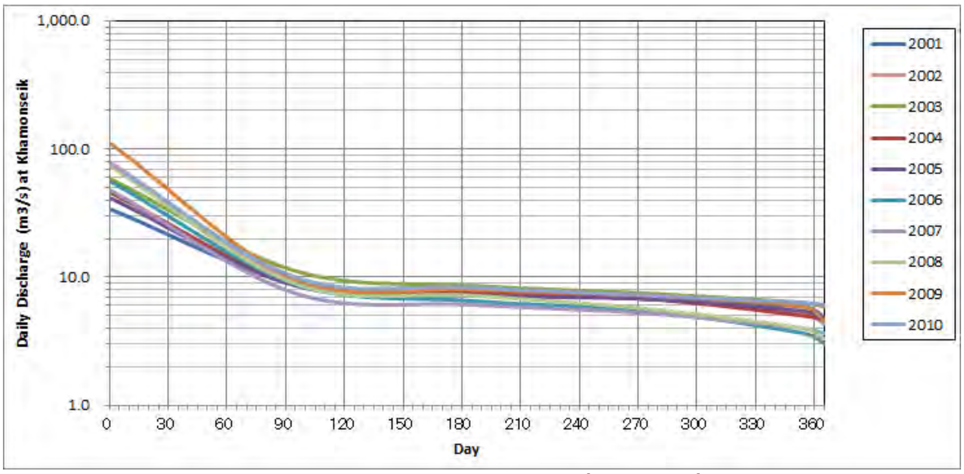
Source: JICA Study Team based on the data from BRS of DPWH

FIGURE 10.7-12 FLOW REGIME OF LASANG RIVER DURING RECENT 10 YEARS

TABLE 10.7-8 FLOW REGIME OF TALOMO RIVER DURING RECENT 10 YEARS

Year	Drainage Area (km^2)	Daily Discharge (m^3/s)							Coefficient of River Regime	Remarks
		Max.	High Dischage	Normal Discharge	Low Discharge	Drought Discharge	Min.	Mean		
			95th day	185th day	275th day	355th day				
2001	165	34	9	8	7	6	5	9	7.0	
2002	165	78	9	7	7	5	4	9	18.1	
2003	165	58	11	9	7	6	6	10	9.9	
2004	165	45	9	7	7	5	5	9	9.7	
2005	165	41	9	7	7	5	5	8	8.5	
2006	165	56	9	7	5	4	3	8	18.3	
2007	165	48	7	6	5	4	4	7	13.0	
2008	165	73	9	7	6	4	3	8	22.0	
2009	165	109	10	8	7	6	4	10	24.3	
2010	165	76	10	8	7	6	6	10	12.5	
Mean	-	62.0	9.0	7.0	7.0	5.0	5.0	9.0	12.4	

Source: JICA Study Team based on the data from BRS of DPWH



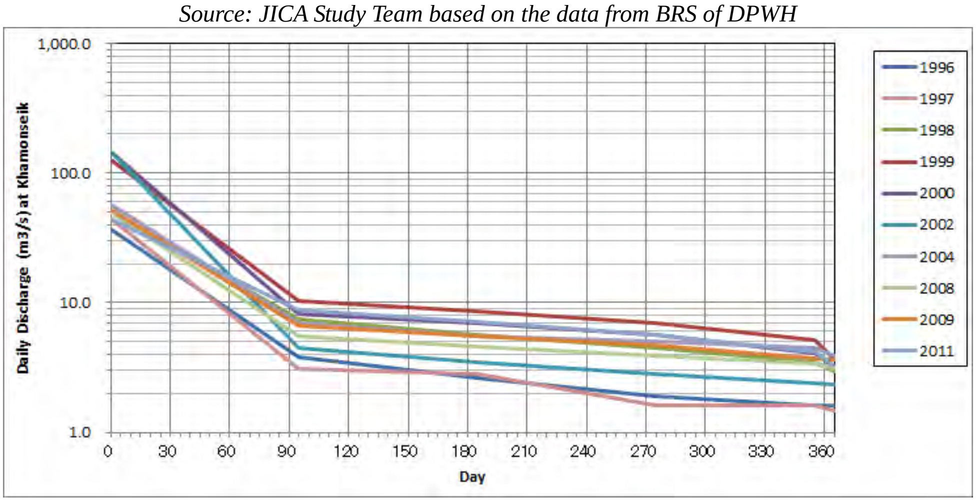
Source: JICA Study Team based on the data from BRS of DPWH

FIGURE 10.7-13 FLOW REGIME OF TALOMO RIVER DURING RECENT 10 YEARS

TABLE 10.7-9 FLOW REGIME OF LIPADAS RIVER DURING RECENT 10 YEARS

Year	Drainage Area (km^2)	Daily Discharge (m^3/s)							Coefficient of River Regime	Remarks
		Max.	High Dischage	Normal Discharge	Low Discharge	Drought Discharge	Min.	Mean		
			95th day	185th day	275th day	355th day				
1996	149	36	4	3	2	2	2	4	22.7	
1997	149	44	3	3	2	2	1	3	29.7	
1998	149	50	8	6	5	3	3	8	16.9	
1999	149	125	10	9	7	5	4	10	34.6	
2000	149	143	8	7	6	4	3	8	45.4	
2002	149	141	5	3	3	2	2	5	59.9	
2004	149	57	7	6	5	4	4	7	14.6	
2008	149	49	6	5	4	3	3	6	15.7	
2009	149	52	7	6	5	4	4	7	14.2	
2011	149	44	9	7	6	4	3	8	13.5	
Mean	-	74.0	7.0	5.0	4.0	3.0	3.0	7.0	24.7	

Source: JICA Study Team based on the data from BRS of DPWH

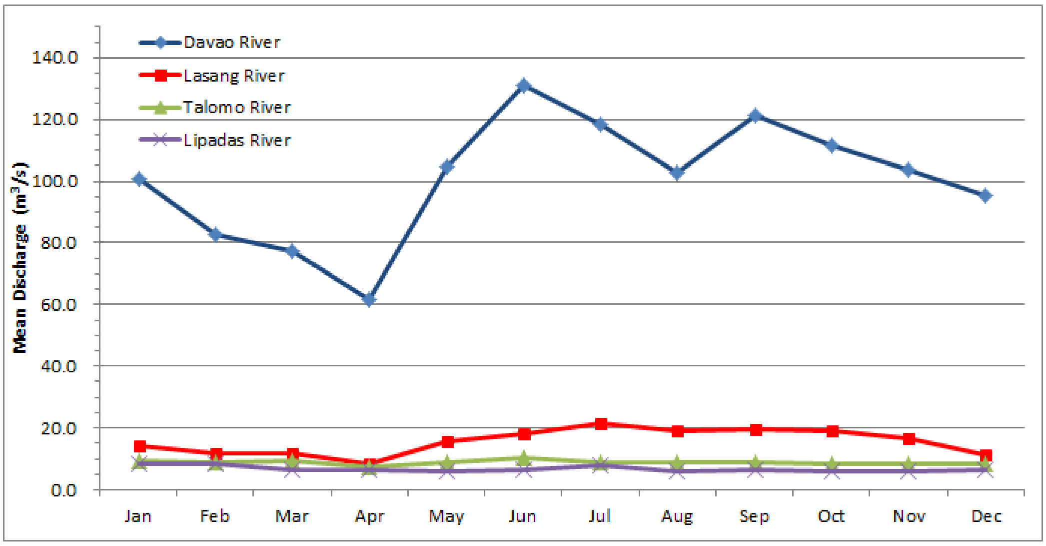


Source: JICA Study Team based on the data from BRS of DPWH

FIGURE 10.7-14 FLOW REGIME OF LIPADAS RIVER DURING RECENT 10 YEARS

(2) Monthly Flow Pattern of Major Rivers

The mean monthly flow pattern from the data of recent 10 years at 4 river gauging stations are shown in **Table 10.7-10** and **Figure 10.7-15**. Similar to the pattern of rainfall, the monthly flow pattern is slightly greater during May to October which the thunderstorms are easy to occur. (See **Figure 10.7-15**.)



Source: JICA Study Team based on the data from BRS of DPWH

FIGURE 10.7-15 MEAN MONTHLY FLOW PATTERN AT RELATED RIVERS

TABLE 10.7-10 MEAN MONTHLY FLOW PATTERN AT RELATED RIVERS

River: Davao River

Station: Davao

Year	Drainage Area (km²)	Monthly Mean Discharge (m³/s)												Annual Mean Discharge
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
		1	2	3	4	5	6	7	8	9	10	11	12	
1986	1,683	155.3	142.9	135.0	127.4	126.9	148.4	157.6	149.6	183.1	123.0	125.7	129.7	1,704.7
1994	1,683	127.2	131.3	133.5	138.4	143.8	137.1	124.7	124.7	139.5	139.1	120.5	128.0	1,587.9
2002	1,469	134.6	63.8	81.8	31.9	144.4	191.5	79.5	134.2	104.0	128.4	108.8	57.8	1,260.8
2003	1,469	50.3	94.3	83.1	33.4	82.4	84.5	133.3	136.3	102.4	144.8	93.8	136.1	1,174.7
2004	1,469	64.5	64.1	63.5	60.6	104.4	129.8	161.1	68.9	178.9	73.6	49.4	91.8	1,110.5
2005	1,469	72.6	42.9	37.7	37.8	74.9	106.3	74.0	51.8	80.4	84.5	67.5	73.3	803.6
2006	1,469	59.6	66.5	86.3	29.0	55.4	102.0	55.0	87.5	136.5	161.8	87.5	50.3	977.3
2007	1,469	92.8	49.0	36.4	33.5	137.1	116.0	102.5	73.1	46.9	52.0	118.0	68.3	925.4
2008	1,469	79.0	64.3	48.1	36.8	59.7	144.4	135.3	78.8	182.7	130.2	112.7	121.3	1,193.2
2009	1,469	171.2	106.0	68.8	88.4	118.9	153.3	158.9	122.8	60.5	76.8	155.1	97.0	1,378.0
Mean	-	100.7	82.5	77.4	61.7	104.8	131.3	118.2	102.8	121.5	111.4	103.9	95.4	1,211.6

River: Lasang River

Station: Lasang

Year	Drainage Area (km²)	Monthly Mean Discharge (m³/s)												Annual Discharge
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
		1	2	3	4	5	6	7	8	9	10	11	12	
1986	354	25.8	25.4	27.5	16.2	7.0	10.1	37.2	12.3	22.8	20.7	21.4	4.7	231.2
1987	354	5.5	7.5	-	3.1	2.0	11.9	15.1	41.0	-	16.8	14.8	15.2	-
2003	344	7.5	10.7	8.5	6.2	14.0	10.8	20.2	21.6	15.4	14.1	14.2	21.0	164.0
2004	344	9.3	8.3	12.0	6.4	11.0	19.4	14.5	7.7	18.4	8.3	5.6	5.6	126.6
2005	344	4.5	4.1	4.3	4.1	28.1	8.8	24.8	17.7	22.8	14.3	12.7	9.0	155.2
2006	344	7.7	10.0	11.5	5.9	8.6	20.8	8.6	21.3	26.6	36.9	18.7	7.4	184.0
2007	344	20.8	8.2	8.2	7.5	32.3	19.1	14.8	14.3	7.1	11.4	31.1	15.0	189.8
2008	344	12.3	17.6	16.4	8.4	20.2	29.1	25.0	15.8	34.8	24.1	21.9	15.1	240.9
2009	344	37.2	18.8	13.5	20.4	19.1	33.4	24.4	17.8	7.8	9.4	16.1	8.7	226.7
2010	344	9.3	6.3	5.8	6.3	13.9	16.8	29.6	23.2	19.1	32.6	11.9	10.5	185.3
Mean	-	14.0	11.7	12.0	8.5	15.6	18.0	21.4	19.3	19.4	18.9	16.8	11.2	189.3

River: Talomo River

Station: Talomo

Year	Drainage Area (km²)	Monthly Mean Discharge (m³/s)												Annual Mean Discharge
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
		1	2	3	4	5	6	7	8	9	10	11	12	
2001	165	7.8	8.8	9.6	7.3	8.4	8.4	8.6	8.8	6.9	9.3	10.4	8.4	102.8
2002	165	13.6	9.6	8.8	7.4	10.3	9.1	7.5	8.7	11.3	6.7	7.5	7.0	107.6
2003	165	9.4	12.4	11.1	8.4	10.4	8.2	10.7	10.4	9.4	9.0	8.6	14.3	122.2
2004	165	8.7	8.6	8.9	7.0	12.6	10.0	9.9	6.5	7.9	6.8	8.2	8.3	103.4
2005	165	9.7	7.3	7.4	7.8	7.6	8.8	7.9	8.0	8.1	8.4	7.9	9.7	98.6
2006	165	9.0	10.7	15.6	5.6	6.9	11.5	5.0	5.6	7.0	10.5	6.1	6.1	99.6
2007	165	7.7	5.9	6.1	5.7	6.3	9.8	9.2	7.2	7.1	6.8	7.7	6.3	85.6
2008	165	7.8	8.1	9.9	7.4	7.6	12.9	8.2	8.8	9.8	7.0	4.7	6.7	98.9
2009	165	11.4	11.3	8.3	8.8	8.1	13.3	9.6	8.1	7.3	8.4	11.4	9.7	115.8
2010	165	9.7	7.1	8.4	7.9	7.7	9.5	11.6	14.8	11.9	8.7	8.6	9.0	114.8
Mean	-	9.5	9.0	9.4	7.3	8.6	10.1	8.8	8.7	8.7	8.2	8.1	8.6	104.9

River: Lipadas River

Station: Lipadas

Year	Drainage Area (km²)	Monthly Mean Discharge (m³/s)												Annual Mean Discharge
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
		1	2	3	4	5	6	7	8	9	10	11	12	
1996	149	5.9	6.2	2.0	3.8	2.8	4.7	2.9	5.7	3.2	2.5	4.5	2.3	46.7
1997	149	6.2	4.7	4.7	3.0	4.8	2.6	2.7	2.0	3.4	2.2	2.2	2.5	41.0
1998	149	9.4	7.2	5.0	7.8	5.9	6.4	22.0	3.7	7.4	6.7	7.4	8.7	97.7
1999	149	16.0	8.1	12.3	10.6	8.4	6.8	10.8	9.2	8.4	9.2	8.6	16.9	125.4
2000	149	9.4	18.8	7.7	12.0	8.3	8.8	7.0	6.2	4.9	7.3	6.4	5.8	102.5
2002	149	9.8	11.1	5.7	3.3	4.2	3.9	2.9	3.3	5.9	4.6	4.5	4.2	63.3
2004	149	6.8	6.4	7.4	4.7	7.4	6.4	9.8	5.7	11.9	6.2	6.5	7.7	87.0
2008	149	5.9	5.9	5.6	3.9	3.6	8.9	4.6	5.9	6.8	6.4	7.1	5.0	69.6
2009	149	9.1	7.0	7.8	6.5	5.6	6.3	7.7	9.2	5.8	5.2	4.7	5.1	80.1
2011	149	6.3	8.3	7.5	9.6	8.6	8.5	7.8	9.2	8.4	7.6	5.8	4.9	92.4
Mean	-	8.5	8.4	6.6	6.5	6.0	6.3	7.8	6.0	6.6	5.8	5.8	6.3	80.6

Source: JICA Study Team based on the data from BRS of DPWH

(3) Tidal Level around Davao Gulf

The invert elevations of outlets of nearest rivers (the Lasang River) and main drains to the Gulf are are likely to affect the sea level. Hence the discharge capacities depend on the tide levels, i.e. high capacity at low tide and low at high tide.

For the Davao City, the observed tide record at the Station Ana Port shows the variation of tidal levels as shown in **Table 10.7-11**.

TABLE 10.7-11 TIDAL LEVEL AT DAVAO CITY (STA. ANA PORT)

Tide Condition	Elevation in meter above MLLW
Mean Higher High Water (MHHW)	1.536
Mean High Water (MHW)	1.407
Mean Sea Level (MSL)	0.755
Mean Low Water (MLW)	0.102
Mean Lower Low Water (MLLW)	0.000

Source: Storm Drainage Master Plan, Davao City, Aug 1998

10.7.4 Flood Conditions

In Davao City, drainage several projects (such as, dredging of Davao river, Davao City Storm Drainage Project, etc.) have been implemented in the past. Nevertheless, the flooding has been occurring frequently in Davao City.

Generally, floods can be classified into three types:

- Riverine floods in the river;
- Localized floods in urban area due to a combination of factors, such as cloudburst, saturated soil, poor infiltration rates and inadequate or poorly built infrastructure (such as blocked drains);
- Flooding due to typhoon and storm surge in the coastal areas.

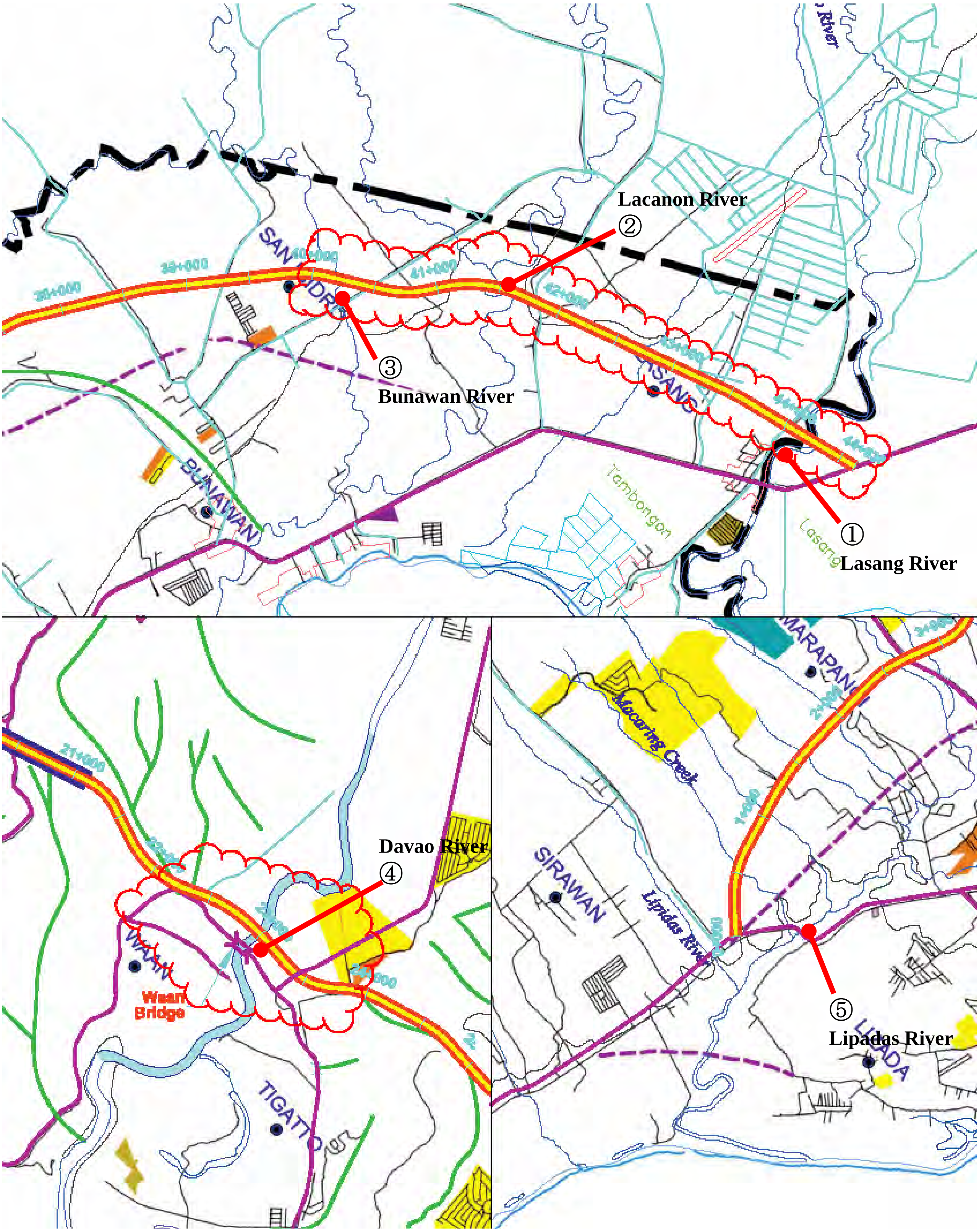
Surroundings of this proposed bypass road are hilly and lowland areas, and the major factors of floods are estimated from riverine floods in the river. According to the interview survey to local inhabitants, following locations occurred floods in the past as shown in **Table 10.7-12** and **Figure 10.7-16**.

From this interview Result, it is predicted that flood risks at surrounding areas from Bunawan River to Lasang River and Davao River are very high.

TABLE 10.7-12 INTERVIEW SURVEY RESULTS

Interviewed Location	Interview Results	Remarks
① Lasang River	Past Flood height: Ground Level + 0.70m (max) Frequency of overbank: Small floods are 6 times/year. Big flood is 1 time/2years.	Along proposed bypass
② Lacanon River	Past Flood height: Ground Level + 0.80m (max) Frequency of overbank: 4 times/2013	Along proposed bypass
③ Bunawan River	Past Flood height: Ground Level + 0.30m (max) Frequency of overbank: only 1 time (June 2011)	Along proposed bypass
④ Davao River	Past Flood height: Ground Level + 1.00m (max) Frequency of overbank: only 2 times (at Dec. 2012)	Along proposed bypass
⑤ Lipadas River	Past Flood height: Ground Level + 1.60m (max) Frequency of overbank: only 2 times (1987 and 2007)	Location away from proposed bypass (existing bridge of national road)

Source: JICA Study Team



Source: JICA Study Team

FIGURE 10.7-16 LOCATION AND RESULTS OF INTERVIEW SURVEY

10.7.5 Estimation of Probable Floods and Water Levels of Major Rivers

(1) Probable Floods at Gauge Stations

Past annual maximum discharges (extremal values) of 5 river gauging stations for the design discharges are collected as shown in **Table 10.7-13**.

TABLE 10.7-13 COLLECTION DATA LIST FOR ANNUAL MAXIMUM DISCHARGE

River Name		Davao			Lasang			Talomo			Lipadas			Matina		
Drainage area (old) km^2		1683 (-1999)			354 (-1989)			-			-			-		
Drinage area km^2		1469 (2001-)			344 (2002-)			165			149			48		
Extreme Value Data		Date	Discharge (m^3/s)	Water Level (m)	Date	Discharge (m^3/s)	Water Level (m)	Date	Discharge (m^3/s)	Water Level (m)	Date	Discharge (m^3/s)	Water Level (m)	Date	Discharge (m^3/s)	Water Level (m)
	1	*1985/5/6*	*384.70*	-	*1985/7/10*	*126.52*	-	1986/3/10	78.00	1.90	1986/1/31	53.88	2.55	1959/10/28	35.00	2.04
	2	*1986/3/31*	*140.67*	-	*1986/1/31*	*310.57*	-	1987/2/5	69.00	1.80	1987/2/5	46.75	2.40	1960/8/27	114.20	3.00
	3	*1987/10/1*	*181.16*	-	*1987/8/21*	*141.49*	-	1988/10/23	37.00	1.40	1988/6/26	71.25	2.90	1961/1/31	21.20	1.80
	4	*1988/3/1*	*181.16*	-	*1988/11/25*	*157.04*	-	1989/4/17	78.00	1.90	1989/4/19	71.25	2.90	**1962/1/29**	**146.89**	**3.33**
	5	*1990/8/12*	*185.87*	-	2003/9/13	351.50	5.50	1990/11/9	16.40	1.00	1990/1/13	25.00	1.90	1963/3/3	6.40	1.40
	6	*1992/9/1*	*387.54*	-	2004/6/8	351.50	5.50	1991/6/29	87.00	2.00	1991/6/25	25.83	1.73	1964/2/15	5.30	1.35
	7	*1993/2/6*	*225.63*	-	2005/10/31	467.20	4.91	1993/7/3	48.20	1.56	1992/8/9	26.90	1.76	1966/8/12	12.20	1.60
	8	*1994/10/1*	*163.66*	-	**2006/6/16**	**774.00**	**5.80**	1998/1/6	33.70	1.34	1993/7/27	46.15	2.20	1967/6/29	21.20	1.80
	9	*1999/9/14*	*551.64*	-	2007/11/11	385.50	4.00	1999/12/12	157.00	2.58	1994/6/8	37.15	2.00	1968/1/13	143.80	-
	10	2001/3/28	726.00	4.30	2008/6/29	547.30	4.54	2000/2/16	205.00	2.90	1995/2/8	41.65	2.10	1969/7/1	9.20	1.50
	11	**2002/1/4**	**1360.20**	**5.98**	2009/1/15	346.30	3.86	2001/6/1	67.00	2.00	1996/1/2	41.65	2.10	1970/9/24	46.20	2.20
	12	2003/12/22	627.10	3.98	2010/10/15	385.50	4.00	2002/1/4	175.00	2.70	1997/3/6	59.65	2.50	-	-	-
	13	2004/9/26	864.00	4.70	-	-	-	2003/12/22	97.00	2.10	1998/7/7	55.20	2.10	-	-	-
	14	2005/6/18	355.60	2.98	-	-	-	2004/5/9	108.00	2.20	1999/12/12	229.20	4.50	-	-	-
	15	2006/3/9	678.50	4.15	-	-	-	2005/10/22	78.00	1.90	2000/2/16	261.20	4.80	-	-	-
	16	2007/1/9	719.60	4.28	-	-	-	2006/3/5	108.00	2.20	2001/4/3	200.45	4.20	-	-	-
	17	2008/7/4	651.00	4.06	-	-	-	2007/12/11	97.00	2.10	2002/2/19	141.45	3.50	-	-	-
	18	2009/1/15	474.30	3.44	-	-	-	2008/3/10	145.00	2.50	2003/1/24	56.10	2.12	-	-	-
	19	-	-	-	-	-	-	**2009/6/29**	**285.50**	**3.50**	**2004/9/28**	**304.25**	**5.00**	-	-	-
	20	-	-	-	-	-	-	2010/12/6	78.00	1.90	2008/11/14	126.80	3.08	-	-	-
	21	-	-	-	-	-	-	-	-	-	2009/3/6	222.50	4.20	-	-	-
	22	-	-	-	-	-	-	-	-	-	2010/11/29	272.00	4.70	-	-	-
	23	-	-	-	-	-	-	-	-	-	2011/10/7	159.75	3.50	-	-	-

Note: The annual maximum value of old stations' data at Davao and Lasang Rivers is adjusted by the ratio of basin area of new and old stations.

Source: JICA Study Team based on the data from BRS of DPWH

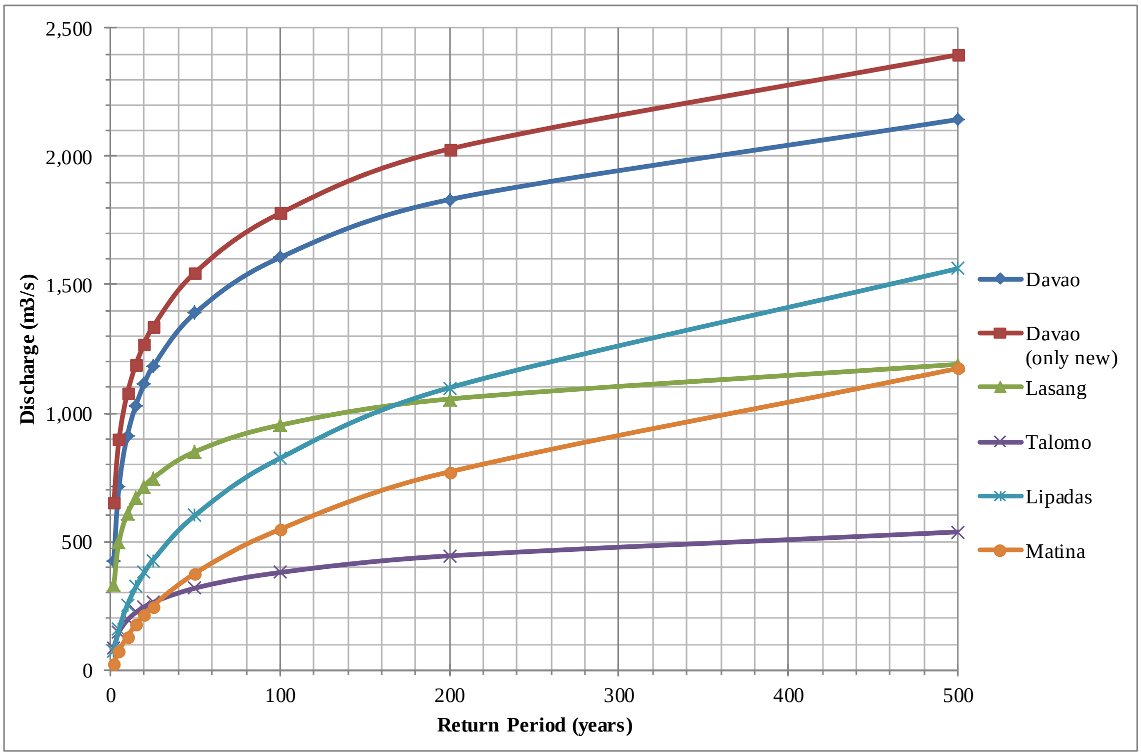
The probable discharges are calculated according to the followings;

- To select the appropriate model for probability distribution from the several methods. In this study, the smallest SLSC (Standard Least-Square Criterion) is adopted from calculation results.
- Calculation return periods are for 2, 5, 10, 15, 20, 25, 50, 100, 200 and 500 year.

The results of probable discharge at 5 discharge-gauge stations (Davao, Lasang, Talomo, Lipadas and Matina) are shown in **Table 10.7-14**.

TABLE 10.7-14 COMPUTATION OF PROBABLE FLOODS AT EXISTING GAUGE STATIONS

Station Name	Davao	Davao (only new)	Lasang	Talomo	Lipadas	Matina	Remarks
Drainage Area (km^2)	1,469	1,469	344	165	149	48	
Return Period (years)	Probable Discharge (m^3/s)						
2	427	651	331	86	71	25	
5	713	896	498	147	158	72	
10	914	1,078	608	194	253	131	
15	1,031	1,189	670	224	323	176	
20	1,115	1,271	713	245	379	214	
25	1,181	1,336	747	262	427	248	
50	1,390	1,548	850	318	602	376	
100	1,606	1,778	953	379	824	547	
200	1,832	2,029	1,055	444	1,099	772	
500	2,144	2,396	1,190	537	1,563	1,174	
Applied probability distribution curve	Generalized extreme value distribution	Generalized extreme value distribution	Gumbel distribution	SQRT-exponential type maximum distribution	3-parameter log-normal distribution (Quantile method)	3-parameter log-normal distribution (Quantile method)	



Source: JICA Study Team

(2) Probable Floods at Crossing Points of Major Rivers

The discharges at proposed crossing points (bridge sites) are calculated by multiplying the proportion of the catchment area of each catchment area to the probable discharges of each gauge stations upstream. (Method by the "specific discharge") Probable discharge used for the hydraulic calculation is shown in **Table 10.7-15**.

TABLE 10.7-15 PROBABLE FLOODS AT CROSSING POINT OF MAIN RIVERS

Station Name		Davao	(Davao)	Lasang	(Lasang)	Talomo	(Talomo)	Lipadas	(Lipadas)	(Bato)	Matina	(Matina)	(Malogbok)	Remarks
Drainage Area	km^2	1,469	1,673.4	344	412.7	165	170.1	149	41.0	63.8	48	17.2	15.3	
Probable Discharge at Return Period	m^3/s													
	2	651	741.6	331	397.1	86	88.7	71	19.5	30.4	25	9.0	8.0	
	5	896	1020.7	498	597.4	147	151.6	158	43.4	67.6	72	25.9	22.9	
	10	1,078	1228.0	608	729.3	194	200.0	253	69.6	108.3	131	47.0	41.7	
	15	1,189	1354.4	670	803.7	224	231.0	323	88.8	138.2	176	63.2	56.1	
	20	1,271	1447.8	713	855.3	245	252.6	379	104.2	162.2	214	76.8	68.2	
	25	1,336	1521.9	747	896.1	262	270.1	427	117.4	182.8	248	89.1	79.0	
	50	1,548	1763.4	850	1019.6	318	327.9	602	165.5	257.7	376	135.0	119.8	for Design
	100	1,778	2025.4	953	1143.2	379	390.8	824	226.6	352.7	547	196.4	174.3	for Check
	200	2,029	2311.3	1,055	1265.6	444	457.8	1,099	302.2	470.4	772	277.2	246.0	
	500	2,396	2729.4	1,190	1427.5	537	553.7	1,563	429.8	669.0	1,174	421.6	374.1	

Source: JICA Study Team

From each flow regime of 4 river, the normal discharge and low discharge are also estimated as shown in the **Table 10.7-16**.

TABLE 10.7-16 NORMAL AND LOW DISCHARGE AT CROSSING POINT OF MAIN RIVERS

Crossing Points of Proposed Bypass	Recorded Year	at Gauging Station			at Crossing Points of Bypass				
		Drainage Area (km^2)	Normal Discharge (m^3/s)	Low Discharge (m^3/s)	Drainage Area (km^2)	Normal Discharge		Low Discharge	
						($m^3/s/km^2$)	(m^3/s)	($m^3/s/km^2$)	(m^3/s)
Davao	1993-2009	1,469	79.0	64.0	1,673.4	0.05198	87.0	0.04175	69.9
Lasang	1986-2010	344	10.0	7.0	412.7	0.02834	11.7	0.01928	8.0
Talomo	2001-2010	165	7.0	7.0	170.1	0.04528	7.7	0.03954	6.7
Lipadas 1	1996-2011	149	5.0	4.0	41.0	0.03540	1.5	0.02872	1.2
2					63.8		2.3		1.8
Average Discharge per 1 km^2					1	0.04025	-	0.03232	-

Source: JICA Study Team

(3) Discharge Calculation for other Rivers and Channels

Following the DPWH design criteria, Rational Formula will be used for catchment areas less than 20 km^2 and aside from the Probable Flood Method or Flood Frequency Analysis, Unit Hydrograph method will be used to waterway crossings with catchment areas larger than 20 km^2.

Probable Flood Method as shown in the previous section is conducted to 5 gauged rivers in the project alignment, Davao, Lasang, Talomo and 2 Lipadas Rivers.

For ungauged waterways, design floods were estimated by Rational Formula and Unit hydrograph method by first measuring the watershed parameters.

1) Watershed Parameter

The following topographic parameters are determined: catchment area (A), the water course length (L), and the difference in elevation from the farthest watershed point up to the point of interest (a bridge site, culvert or outfall, H).

In flood plain areas, wherein drainage boundaries can hardly be established for each culvert, drainage is satisfied by a group of balancing culverts.

2) Rational Method

$$Q_y = 0.278 C I_{t,y} A$$

Where:

Q_y	–	Peak discharge (m^3/s),
C	–	Runoff coefficient (**Table 10.2-5**),
$I_{t,y}$	–	Rainfall intensity (mm/hr) for time of concentration (t_c), and
A	–	Catchment area (km^2). The catchment area of a major or minor waterway

3) Unit Hydrograph Analysis

Unit hydrograph approach is generally accepted for larger areas and the method involved derivation of dimensionless hydrograph of the gauged rivers in the region. From this dimensionless hydrograph, the unit hydrograph at the bridge site was derived. With the available design rainfall data and watershed characteristics of the project area, the unit hydrograph is converted to design flood hydrograph. In the absence of the recorded dimensionless hydrograph of the gauged rivers in the region, the SCS synthetic unit hydrograph will be adopted for the study as shown in **Figure 10.7-17.**

The above design flood estimates are analytically checked with the actual flood data and flooding estimates based on the actual or locally observed information.

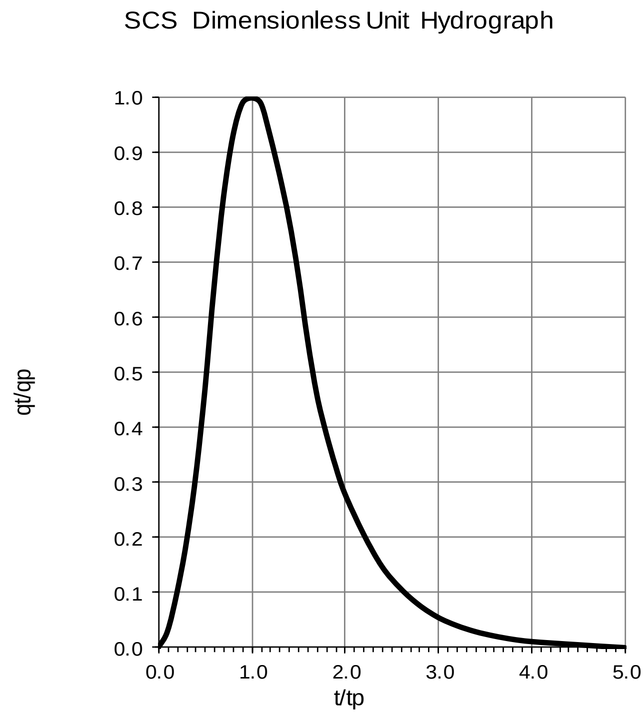


FIGURE 10.7-17 SCS DIMENSIONLESS UNIT HYDROGRAPH

4) Adopted Design Discharge

Adopted design discharge is the computed design discharge using the above methodology plus allowances for siltation and climate change. Climate change is already considered by increasing the design discharge criteria of culverts as from 10-yr to 15-yr for RCPC and considering a sufficient freeboard to contain 50-yr flood for reinforced concrete box culverts (RCBC) and 25-yr flood for the reinforced concrete pipe culverts (RCPC).

Allowance of 50% was added to the computed design discharge for siltation and debris as the area is prone to slope degradation during heavy rains.

(4) Hydraulic Calculation

1) Calculation Method for Rivers

Hydraulic analysis is carried out to simulate the flood phenomena (High Water Level, etc.) at the related river using HEC-RAS (Hydrologic Engineering Center - River Analysis System) developed by US Army Corps of Engineers, USA.

HEC-RAS has the capability to compute one-dimensional water surface profiles for both steady and unsteady flow. Sub-critical, supercritical and mix flow regime profiles can be calculated.

Water surface profiles are computed from one cross section to the next by solving the energy equation using standard-step method. Energy losses are evaluated by friction (Manning's equation) and contraction/expansion coefficients. HEC-RAS requires inputs for boundary conditions of upstream discharge and either downstream water level or known energy gradient.

HEC-RAS analysis for the identified bridge sites in the alignment is shown in **Table 10.7-17.**

TABLE 10.7-17 BRIDGE HYDRAULIC RESULT SUMMARY

Watershed No.	DESCRIPTION			WA	ADOPTED DEIGN FLOOD, m3/sec		Design Discharge Computation Method	Adopted Design Discharge ,Qd	HEC-RESULTS	
	Survey Waterway No.	Station		km^2	50-yr	100-yr		m^3/sec	**50-YR FLOOD LEVEL, m**	ADOPTED BRIDGE SPAN
2	R1	0+451.22	Macaring Creek-R1	1.86	88.86	97.47	Rational Formula	88.86	**24.65**	Refer to Plan & Profile
3	R2	0+984.35	Creek3-R2	1.12	56.17	61.59	Rational Formula	56.17	**32.05**	Refer to Plan & Profile
5	R3	2+000.00	Creek5-R3	6.24	231.24	254.22	Rational Formula	231.24	**35.18**	Refer to Plan & Profile
6	R4	2+600.00	Bayabas Creek-R4	19.53	643.93	708.84	Rational Formula	643.93	**31.76**	Refer to Plan & Profile
7	R5	2+800.00	Tributary of Bayabas Creek-R5	4.23	176.47	193.79	Rational Formula	176.47	**28.95**	Refer to Plan & Profile
12	R6	5+020.00	Lubogan River-R6	65.55	552.01	606.44	Hydrograph	552.01	**48.70**	Refer to Plan & Profile
13	R7	6+080.00	Lipadas River- R7	43.63	326.65	364.91	Hydrograph	326.65	**105.51**	Refer to Plan & Profile
17	R8	10+764.57	Aclihan Creek-R8	3.07	111.80	122.93	Rational Formula	99.73	**128.44**	
17	R9	11+587.19	Talomo River Tributary-R9	3.07	111.80	122.93	Rational Formula	99.73	**144.04**	
17	R10	12+300.00	Talomo River-R10	3.07	855.72	951.95	Hydrograph	855.72	**127.36**	Refer to Plan & Profile
26	R15	22+950.00	Davao River-R15	1,718.26	2,645.10	3,038.10	Probable Flood	2,645.10	**11.89**	Refer to Plan & Profile
36	R16	32+600.00	Kumonal Creek-R16	7.65	199.24	219.96	Rational Formula	199.24	**24.71**	Refer to Plan & Profile
41	R17	40+325.00	Tagurot-Bunawan River-17	59.88	320.43	356.12	Hydrograph	320.43	**12.47**	Refer to Plan & Profile
42	R18	41+535.00	Lacanon River-18	92.25	340.66	382.85	Hydrograph	340.66	**11.24**	Refer to Plan & Profile
43	R19	42+790.00	Creek42-19	4.28	177.60	195.04	Rational Formula	177.60	**8.34**	Refer to Plan & Profile
44	R20	44+320.00	Lasang River-20	427.30	1,529.40	1,714.80	Probable Flood	1,529.40	**6.90**	Refer to Plan & Profile

Note: With a more detailed survey the above results need to be re-assess during the next Phase of the Study

2) Calculation Method for Culverts

Based on the basic continuity equation Q=AV, hydraulic analysis of structures like the RCPC/RCBC, side ditches, and irrigation canals or re-aligned waterways were conducted.

The above structures are referred as closed conduits. Closed conduits are designed for the condition of flowing full but usually they are flowing less that they are considered as open channels.

Construction slopes flatter than the hydraulic gradient will cause the conduit to run pressure for the design Q that a consideration be given in increasing the size. In steeper construction slope, the conduit may not flow full that a smaller size may be considered.

The following are criteria for design of closed conduit cross-drains adopted for the road project:

a) Minimum slope of 0.20% is recommended for extremely flat terrain as required for the actual outfall elevation.

b) For rolling mountainous terrain, cross-drains are designed for appropriate inlet control works and laid with slope that the computed outlet velocity will not exceed the damaging velocity of 3 m/s. However, in extreme cases where outlet velocity of 3 m/sec. to 5 m/sec cannot be avoided, dumped rock with a distance 4 to 6 m from the outlet is recommended. Outlet velocities beyond 5 m/s will require outlet energy dissipators. For the project area, the use of stone masonry step energy dissipators or box gabions are recommended as masonry stones and smaller stones for gabions are abundant in the area.

c) A minimum of 910 mm dia. is adopted for new installations taking into consideration the condition and performance of the existing cross-drains in the area in relation to the expected debris flow.

d) In areas dictated by some restrictions wherein the use of circular barrel is not feasible as higher discharges or higher debris flows are expected, the use of reinforced concrete box culverts are recommended. In the project area locations where high debris flows are expected, the use of 2-barrel RCBC/RCPC installation will be avoided as much as possible.

e) A minimum of 0.60 meter fill pipe covering is adopted; otherwise an equivalent reinforced concrete box culvert will be adopted in areas where this minimum pipe fill will not be met.

f) Inlet and outlet works are determined through the Headwater Depth (HW) ratio to the depth of Depth of culvert (D). Headwater depth is the vertical distance from the culvert invert to the water surface elevation permissible in the approach channel.

Where:

$\frac{HW}{D}$	$\leq$	1.2	entrance not submerged, no protection works needed at the entrance of culvert
$\frac{HW}{D}$	$\geq$	1.5	necessary to protect the inlet with riprap or stone masonry
HW	>	1.0	not usual for flat terrain

Generally, inlet control exists when the ability of the culvert pipe barrel to carry the flow exceeds the ability of the water to enter the culvert though the inlet. Outlet control exists when the ability of the pipe barrel to carry water away from the outlet is less than the flow that can enter the inlet.

In rolling mountainous terrain the inlet is controlling the flow while in flat terrain the outlet governs the amount of flow in pipes.

Sizing of road crossings as governed by either inlet or outlet works is determined with the use of monographs and computer programs available for such purposes.

Design discharge for each cross-drain site was identified. However, in cases were no single waterway line is identified in a certain watershed along the project road, the number of cross-drains were determined according to the required drainage capacity that could satisfy the design discharge for that area. Determination of the number of culvert crossings is simplified by this equation:

$$Np = Qt/Op$$

Where:

NP – total number of cross-drain
Qt – total discharge
Qp – pipe capacity derived from nomographs for outlet or inlet control

In existing cross-drain locations where NpQp < Qt new culvert lines are installed or existing lines are replaced with bigger sizes.

To use a single barrel of multiple barrel installations or an equivalent box culvert dimension is also govern by sufficiency of the ground cover and the expected debris flow.

Using the basic continuity equation, HY-8 is the automated the design methods described in HDS No. 5, "Hydraulic Design of Highway Culverts" FHWA-IP-85-15; HEC No. 14. With the basic inputs as the computed total design discharge, site data which refers to elevations and embankment slope, culvert data which includes culvert type, span and length, original ground and road embankment level, tail water and roadway crossing data, the software automatically analyze to give the headwater elevation, velocity etc. for the given design discharge and section.

Based on the cross-drains hydraulics computation result, the culvert size was determined.

3) Roadside Ditches or Canals

Road on cut sections, on flat terrain wherein embankment height less than 1 meter and on built-up flood areas shall be provided with side ditches.

Channel dimensions, slope and channel velocity are determined as much as possible especially in unlined channels not too severe to cause scouring and erosion and too small to cause deposition of sediments in the channel.

Line ditches such as grouted riprap or concrete lined are recommended in high velocity sections and concrete rectangular covered or without cover canals are recommended in urban areas otherwise, triangular or trapezoidal earth ditches are recommended.

In areas where much sediment load is expected an allowance of at least 50% to 100% is provided to area obtained by Q = AV and road alignment susceptible to underground water capillary actions, underdrains are provided. Results are tabulated in **Appendix 10.7.**

10.8 SLOPE PROTECTION DESIGN

10.8.1 Cut-slope Gradient

The geological features of the project section are underlain by Masuhi Formation (sandstone, shale and conglomerate) of the Tertiary Miocene-Pliocene. Geological features on Masuhi Formation are composed of “Mandog Formation (lithified gravel and sand) and Apo Volcanic Complex (Basalt, andesite, pyroclastic rocks, pyroclastic flow deposits, volcanic mud flow deposits) and Bunawan Limestone” of the Quaternary Pleistocene, and “Tigatto Terrace Gravel and Alluvium (unconsolidated sand and gravel)” of the Quaternary Holocene.

The total length of the proposed road is approximately 44.8 km, including the tunnel section of about 2.3km. Mandog Formation, Bunawan Limestone and Tigatto Terrace Gravel are laid in the section of up to Davao River from the north end point, and Alluvium is laid in the section of Davao River. In addition, Mandog Formation, Bunawan Limestone and Tigatto Terrace Gravel are underlain by Masuhi Formation in the mountain section of up to Matina River from Davao River where is proposed a tunnel. The Apo-Talomo Volcanics of Apo Volcanic Complex extensively overlies the Masuhi Formation in the section of up to south end point from Matina River.

The cut slopes gradient of each stratum above mentioned are recommended as shown in **Table 10.8-1** based on **Table 10.2-7** it is shown in the "Standard Gradient of Cut Slopes".

TABLE 10.8-1 SUGGESTION OF CUT-SLOPE GRADIENTS

Stratum	Geologic Time	Description	Condition of Subsoil and Rocks	Suggested Cut-slope Gradient
Tigatto Terrace Gravel	Holocene	Terrace deposits which are composed of stratified loose sandy gravel	Sandy Soil Mixed with Gravel or Rock Masses	1.0:1.0
Bunawan Limestone	Late Pleistocene	Coralline limestone	Soft-Hard Rock	0.8:1.0
Apo-Talomo Volcanics	Pleistocene	Volcanic ash, volcanic mud flows, pyroclastic flows	Cohesive Soil Mixed with Rock Masses or Cobblestones	1.2:1.0
Mandog Formation	Early-Late Pleistocene	Lithified interbedded sandy soil and cohesive soil, and including thin gravel layers	Sandy Soil, Cohesive Soil, Soft Rock	1.0:1.0
Masuhi Formation	Late Miocene-Early Pliocene	Interbedded sandstone and mudstone, and including thin conglomerate	Soft Rock	0.8:1.0

10.8.2 Cut-slope Protection

The suitable cut slope protection consisting of the planting and slope structures for the each stratum are recommended as shown in **Table 10.8-2**, according to **Figure 10.2-3** (the selection flowchart of slope protection) it is shown in the “Selection Method of Cut Slope Protection”. Incidentally, the slope structures are assumed the case to make steep slopes than the standard slope gradient.

TABLE 10.8-2 SUGGESTION OF SLOPE PROTECTION

Stratum	Geologic Time	Description	Suggested Slope Protection	
			Planting	Slope Structures
Tigatto Terrace Gravel	Holocene	Terrace deposits which are composed of stratified loose sandy gravel	Vegetation Mat (1.0:1.0)	Grating Crib Works using Shotcrete (0.8:1.0)
Bunawan Limestone	Late Pleistocene	Coralline limestone	Vegetation Base Material Spraying (0.8:1.0)	Concrete Pitching (0.5:1.0)
Apo-Talomo Volcanics	Pleistocene	Volcanic ash, volcanic mud flows, pyroclastic flows	Sowing (1.2:1.0)	Grouted Riprap (1.0:1.0)
Mandog Formation	Early-Late Pleistocene	Lithified interbedded sandy soil and cohesive soil, and including thin gravel layers	Vegetation Mat (1.0:1.0)	Grating Crib Works using Shotcrete (0.8:1.0)
			Vegetation Base Material Spraying (1.0:1.0)	Stone/ Rubble-Concrete Masonry (0.5:1.0, Soil Slope Type)
Masuhi Formation	Late Miocene-Early Pliocene	Interbedded sandstone and mudstone, and including thin conglomerate	Vegetation Base Material Spraying (0.8:1.0)	Mortar/Concrete Spraying (Shotcrete) (0.8:1.0)
				Stone/ Rubble-Concrete Masonry (0.5:1.0, Rock Slope Type)

Note: - The planting should be used in case of the suggested cut-slope gradient shown in Table 10.8.1-1. And the slope structures should be used to make steep slopes than the standard slope gradient (excepting the mortar/concrete spraying).

- The assumed slope gradient is shown at the inside of (   ).

Besides, when the suggested slope protections in **Table 10.8-2** are applied, the considerations are as follows.

- Because the applicable conditions of the vegetation mat are different by the products, it is necessary to select the optimum product of the vegetation mat according to hardness of the ground. Therefore, it is desirable to use different products in Tigatto terrace gravel and Mandog formation.
- The thickness of the vegetation base material should be changed according with the hardness of the ground. The general range of changing is "1 cm (in case of N-value 4 roughly)" to "10 cm (in case of soft rock)". Therefore, the thickness of the vegetation base material may be 7 cm in case of Bunawan Limestone, 3 cm in case of Mandog Formation, 5 cm in case of Masuhi Formation.
- The proposed "grating crib works using shotcrete" for Tigatto Terrace Gravel and Mandog formation is assumed the frame cross section 0.3m-square, the frame interval about 2.0m.
- The proposed "stone/rubble-concrete masonry" for Mandog Formation is assumed to be used only at the slope stage of bottom by the soil slope type (slope height 6 m or less, wall thickness 0.6m).
- The proposed “mortar/concrete spraying (shotcrete)” is suitable than the planting (vegetation base material spraying), because Masuhi Formation is prone to weathering when the

long-range stability of the slope is considered.

- The proposed "stone/rubble-concrete masonry" for Masuhi Formation is assumed to be used only at the slope stage of bottom by the rock slope type (slope height 7 m or less, wall thickness 0.45m).

10.8.3 Embankment-slope Gradient

In the project road, the excavated materials of the excavation sections and the tunnel section should be used as banking materials. Therefore, the main banking materials in the section of up to Davao River from the north end point are thought "gravelly soils, sandy soils and cohesive soils" of Mandog formation. The main banking materials of "the vicinity of Davao River of the tunnel east side and the vicinity of Matina River of the tunnel west side" are thought the debris of "sandstone/shale of Masuhi formation" excavated in the tunnel section. And the sandy gravel of "Tigatto terrace gravel" is also thought as the banking material in the vicinity of Matina River. In addition, the main banking materials in the section of up to the south end point from the vicinity of Talomo River are thought "volcanic mud flow deposits and pyroclastic flow deposits" which compose the surface part of Apo Volcanics.

The embankment slopes gradient of each main banking material above mentioned are recommended as shown in **Table 10.8-3** based on "**Table 10.2-9** and **Table 10.2-10**" which are shown in the "10.2.7.6 Standard Slope Gradients for Embankment".

TABLE 10.8-3 SUGGESTION OF EMBANKMENT SLOPE GRADIENTS

Stratum to Obtain	Banking Materials	Unified Soil Classification of ASTM (Material Classification of AASHTO)	Height of Embankment	Suggested Embankment Slope Gradients
Tigatto Terrace Gravel	Sandy Gravel	GW, GP (A-1)	5m or less	1.5:1.0
			5m to 15m	1.8:1.0
Apo-Talomo Volcanics	Silty gravel, Clayey gravel	GM, GC (A-1)	5m or less	1.5:1.0
			5m to 15m	1.8:1.0
Mandog Formation	Silty sand, Clayey sand , Lean clay , Silt	SM, SC, CL, ML (A-2-6, A-2-7, A-4, A-6)	5m or less	1.5:1.0
			5m to 10m	1.8:1.0
Masuhi Formation	Rock debris	GW, GP (A-1)	10m or less	1.5:1.0
			10m to 20m	1.8:1.0

Except the rock debris of Masuhi Formation, the suggested embankment slope gradients which are shown in **Table 10.8-3** is 1.5:1.0 in case of the embankment height of 5m or less, and it is 1.8:1.0 in case of the embankment height of more than 5m. However, there is a possibility that in the future the rock debris of Masuhi formation vary to silty gravel (GM) or clayey gravel (GC), because Masuhi formation is the soft rock that is easy to weathering. Therefore, it is recommended which the embankment slope gradient of the rock debris of Masuhi Formation may be applied at the same conditions (embankment height) with the other banking materials.

10.8.4 Embankment-slope Protection

Based on "10.2.7.7 Slope Protection of Embankment", the slope protection of embankment should be applied the planting in principle, but such the slope protection as the grouted riprap should be applied in the inundation risk sites such of the river flood areas.

In addition, when the rock debris is used as the banking materials, the slope should be overlaid by the soil blanket on embankment slope (Cohesive soil) of the thickness 30 cm or more as shown in **Figure 10.2-14**, except the case of using the grouted riprap as the slope protection.

10.8.5 Design of "Grating Crib Works using Shotcrete"

(1) Design Specification

The design of "Grating Crib Works using Shotcrete" is carried out in a limit state design method according to the below Japanese design standard and the design example.

(a) Guideline for Design and Construction of Grating Crib Works (Revised Edition, Third Edition): October 2013 (issued by Japan Slope Protection Association)

(b) Free Frame Method - Limit State Design Example by Performance Verification System: April 2008 (edited by Free Frame Society)

(2) Partial Safety Factor of Grating Crib Works

The partial safety factor of Grating Crib Works, the values shown in **Table 10.8-4** listed in Appendix Table 1.3 of "Guideline for Design and Construction of Grating Crib Works (Revised Edition, Third Edition)" are applied.

TABLE 10.8-4 PARTIAL SAFETY FACTOR OF GRATING CRIB WORKS

Safety Factor / Limit State	Material Factor γ_m		Partial Factor	Structural Analysis Factor	Load Factor	Structure Factor
	Mortar γ_c	Steel γ_s	γ_b	γ_a	γ_f	γ_i
Ultimate Limit State	1.3	1.0	- Bending/Axis Proof Stress (M_{ud}): 1.15 - Shear Proof Stress served by Mortar (V_{cd}): 1.30 - Shear Proof Stress served by Shear Reinforcement (V_{sd}): 1.10 - Proof Stress to Diagonal Compression Failure (V_{wcd}): 1.30	1.0	1.2	1.2
Service Limit State	1.0	1.0	1.0	1.0	1.0	1.0

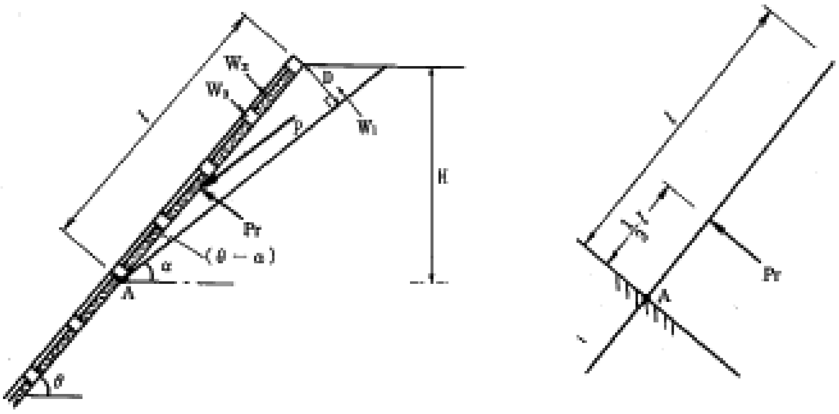
Source: Guideline for Design and Construction of Grating Crib Works (Revised Edition, Third Edition): October 2013 (issued by Japan Slope Protection Association)

(3) Design Method

As shown in **Figure 10.8-1**, the grating crib is designed as a cantilever which the fixed point is the intersection of the vertical frame and the slip line, because a straight slide line is thought from shoulder of slopes.

It is thought the design external force to act on the grating crib is calculated as a concentrated load by the sliding force, and the design external force is calculated by the following expression.

$P = \triangle Fs \times W \times \sin\alpha$
$P_r = P \times \sin(\theta - \alpha)$
$P_d = \gamma_f \times P_r$



Source: Guideline for Design and Construction of Grating Crib Works (Revised Edition, Third Edition): October 2013 (issued by Japan Slope Protection Association)

FIGURE 10.8-1 STRAIGHT SLIDE LINE FROM SHOULDER OF SLOPES

Where;
- P = slip surface direction working load for the grating crib
- P_r = component force working at right angles to the grating crib
- P_d = design load (slip load)
- γ_t = load factor
- W = total weight of the slip (working load)
  - $W = W_1 + W_2 + W_3$
  - W_1 = weight of the slip clod
  - W_2 = weight of the inside material of grating crib
  - W_3 = weight of the grating crib
- α = angle of inclination of the slip surface (slip angle)
- θ = angle of inclination of the slope
- $\triangle F_s$ = quantity of the safety factor that should be increased

The quantity of the safety factor that should be increased is the difference between the planning safety factor and the status quo safety factor. Basically, because the grating crib will be constructed sequentially after cut of slope, the assumption of the status quo safety factor 1.0 is sufficiently safe side. Therefore, in case of the planning safety factor 1.2, "the quantity of the safety factor that should be increased" is "$\triangle Fs = 1.2 - 1.0 = 0.2$".

The action position of slip load is the position of l / 3 from "A point" where the slip surface and the vertical frame intersect.

Therefore, in case of a cantilever which the point A is fixed end, the design bending moment M_d is given by the following equation; $M_d = -P_d \times l/3$

(4) Design Calculation

1) Design Calculation Model

- Scale of slip; depth D = 1.0m, length l = 6.7m
- Sizes of "Grating Crib Works using Shotcrete"; cross section 300×300mm, span 2000×2000mm
- Slope gradient; 0.8 : 1.0

The design calculation model is shown in **Figure 10.8-2**.

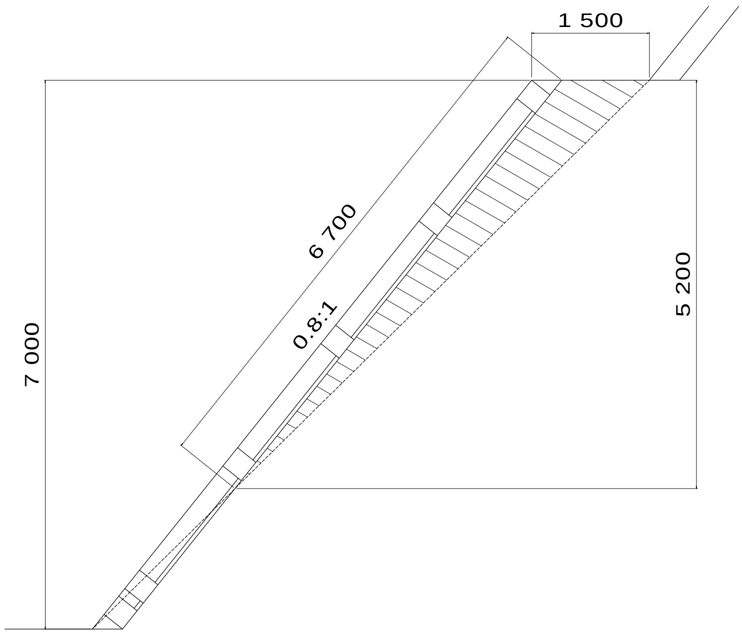


FIGURE 10.8-2 DESIGN CALCULATION MODEL DIAGRAM

2) Design Condition

(a) Unit weight

- Slip clod; γ_1= 20kN/m^3
- Inside material of grating crib (Vegetation Base Material Spraying); γ_2 = 14kN/m^3
- Rebar mortar (frame); γ_3 = 23kN/m^3

(b) Rebar

- Characteristic value of the tensile yield strength; f_y = 345N/mm^2
- Material Factor; γ_s = 1.0
- Design tensile yield strength; $f_{yd} = f_y/\gamma_s$ = 345N/mm^2

(c) Mortar

- Characteristic value of compressive strength (specified design strength); f'_{ck} = 18N/mm^2
- Material Factor; γ_s = 1.3
- Design compressive strength; $f'_{cd} = f'_{ck}/\gamma_c$ = 13.85N/mm^2

(d) Slope gradient; θ=51.34° (0.8 : 1.0)

(e) Slip depth; D = 1.0m, length l = 6.7m

(f) Slip length; l = 6.7m

(g) Thickness of Vegetation Base Material Spraying; d'= 0.05m

(h) Frame cross section/Span; 300×300mm/2000×2000mm

(i) Quantity of safety factor that should be increased; △Fs = 0.2

(j) Load Factor at Ultimate Limit State; γf = 1.2

3) Calculation of Slip Angle α

$\sin(\theta - \alpha) = D / l = 1.0 / 6.7 = 0.149$

Due to (θ-α) = 8.57 °, since the θ = 51.34 °, therefore the slip angle α is;

$\alpha = \theta - 8.57° = 51.34° - 8.57° = 42.77°$

Slip height H is;

$$H = l \times \sin\theta = 6.7m \times \sin 51.34° = 5.23m$$

4) Calculation of Working Load W

The working load W is a total of the slip clod W1, the vegetation base material W2 and the grating crib W3;

$$W_1 = 1/2 \times d \times H/\sin\alpha \times l_1 \times \gamma_1$$
$$= 1/2 \times 1.0m \times 5.23m / \sin 42.77° \times 2.0m \times 20\ kN/m^3 = 154.04\ kN$$

where;

l_1 = lateral frame span (2.0m)

$$W_2 = l / l_2 \times d' \times (l_1\text{-}b) \times (l_2\text{-}b) \times \gamma_2$$
$$= 6.7m / 2.0m \times 0.05m \times (2.0m - 0.3m)\times(2.0m - 0.3m) \times 14\ kN/m^3 = 6.78kN$$

where;

l_2 = vertical frame span (2.0m)

b = frame width (0.3m)

$$W_3 = (l + l / l_2 \times (l_1 - b)) \times b \times h \times \gamma_3$$
$$= (6.7m + 6.7m / 2.0m \times (2.0m - 0.3m)) \times 0.3m \times 0.3m \times 23\ kN/m^3 = 18.49kN$$

where;

l_1 = frame height (0.3m)

Therefore;

$$W = W_1 + W_2 + W_3$$
$$= 154.04kN + 6.78kN + 18.49kN = 179.31kN$$

The load P of the slip plane direction acting on the grating crib is calculated by multiplying "the quantity of safety factor that should be increased △Fs" at "the component force of the slip surface direction of the working load".

$$P = \triangle Fs \times W \times \sin\alpha$$
$$= 0.2 \times 179.31kN \times \sin 42.77° = 24.35kN$$

The component force working at right angles to the grating crib is as follow;

$$P_r = P \times \sin(\theta - \alpha)$$
$$= 24.35kN \times \sin(51.34° - 8.57°) = 16.54\ kN$$

5) Calculation of Design Load and Section Force

The design load Pd is calculated for the ultimate limit state, and it is calculated by multiplying the load factor γ_f (1.20) at the working load P_r.

$$P_d = P_r \times \gamma_f$$
$$= 1.20 \times 6.54\ kN = 7.85kN$$

When the action position of design load Pd is the position of l/3 from "A point" where the slip surface and the vertical frame intersect, the maximum bending moment Md of "a cantilever which the point A is fixed end" is as below;

$$M_d = P_d \times l/3$$
$$= 7.85kN \times 6.7m/3 = 17.53\ kNm$$

6) Rebar Amount

(a) Width of the frame; b=300mm

(b) Effective height of the frame; d=235mm

(c) Tensile reinforcement amount As

When the two bars of D13 are placed at up and down, the tensile reinforcement amount is as below.

$$As = 0.0001267 \times 2 = 0.0002534 m^2$$

(d) Reinforcement ratio; $P = As / (b \times d) = 0.0002534 m^2 / (0.3 m \times 0.235 m) = 0.00359$

(e) Balance reinforcement ratio Pb

$\alpha = 0.88 - 0.004 \times f_{ck}'$ (in which; $\alpha \leq 0.68$)
$= 0.88 - 0.004 \times 18\ N/mm^2 = 0.808$, thus; $\alpha = 0.68$

where;
α = coefficient on the balanced reinforcement ratio

$\varepsilon'_{cu} = (155 - f'_{ck}) / 30000$ (in which; $0.0025 \leq \varepsilon'_{cu} \leq 0.0035$)
$= (155 – 18\ N/mm^2) / 30000 = 0.0046$, thus; $\varepsilon'_{cu} = 0.0035$

$P_b = \alpha \times \varepsilon'_{cu}/(\varepsilon'_{cu} + f_{yd} / E_s) \times f'_{cd} / f_{yd}$
$= 0.68 \times (0.0035 / (0.0035 + 345\ N/mm^2 / 200000\ N/mm^2)) \times (13.85 N/mm^2/345\ N/mm^2)$
$=0.0183$
$P = 0.00359 < 0.0137 = 0.75 \times P_b$ OK

where;
E_s = elastic modulus of rebar (200 kN/mm^2)

7) Safety performance Verification

The safety performance Verification is performed on the flexural failure of ultimate limit state.

(a) Design bending proof stress M_{ud}

$\beta = 0.52 + 80 \times \varepsilon'_{cu}$
$= 0.52 + 80 \times 0.0035 = 0.8$

where;
β = coefficient on the height of equality stress block

$k_1 = 1 - 0.003 \times f'_{ck}$ (in which; $k_1 \leq 0.85$)
$= 1 - 0.003 \times 18\ N/mm^2 = 0.95$, thus; $k_1=0.85$

where;
k_1 = reduction coefficient of mortar strength

$k_2 = \beta / 2 = 0.8 / 2 = 0.4$

The ultimate bending proof stress M_u is as below.

$M_u = b \times d^2 \times p \times f_{yd} \times (1 - k_2 / (\beta \times k_1) \times (p \times f_{yd} / f'_{cd}))$
$= 0.3m \times 0.235m^2 \times 0.0046 \times 345000 kN/m^2 \times (1-0.4/(0.8\times0.85)$
$\times (0.0046 \times 345000 kN/m^2 / 13850 kN/m^2)) = 24.52$ kNm

Therefore the design bending proof stress M_{ud} is as below.

$M_{ud} = M_u / \gamma_b = 24.52$ kNm / 1.15 = 21.32 kNm

where;
γ_b = partial factor of ultimate limit state (1.15)

(b) Verification for safety

$\gamma_i \times M_d / M_{ud} = 1.2 \times 17.53$ kNm / 21.32 kNm = $0.99 \leq 1.00$ OK

where;
γ_i = structure factor of ultimate limit state (1.2)

10.9 SCOPE OF CIVIL WORK (SUMMARY)

10.9.1 Scope of Civil Work

The scope of all the civil works are the following;

Road	37.17 km
Bridge	5.13 km
Tunnel	2.28 km
Total	**44.58 km**

	Road	Bridge	Tunnel	Total
Section-I	10,494 m	1,206 m	-	11,700 m
Section-II	13,014 m	1,806 m	2,288 m	17,100 m
Section-III	13,661 m	2,119 m	-	15,780 m
Total	**37,169 m**	**5,131 m**	**2,280 m**	**44,580 m**

10.9.2 Road Section

(1) Road Length

Total road length is 37.17 km, comprised of 10.31km cut section and 5.27 km embankment section.

Cut Section (H>5m)	10.31km
Embankment Section (H>5m)	5.27 km
Low Cut/Embankment Section	21.59 km
Total	**37.17 km**

(2) Number of Intersection

Number of Intersections	
At-grade	18
Overpass	12
Underpass	6

10.9.3 Tunnel Section

(1) Main Tunnel

Total length of tunnel is 2,280m.

Cross Section Type	Length (m)
C1	-
C2	150
D1	1,390
D2	740
Total	**2,280 m**

*Note: See **Figure 10.4.1-2 Cross Section***

(2) Auxiliary Method

All Ground Fasten (AGF) Method = 70m + 70m + 110m = **250m**

(3) Evacuation Tunnel

Total Length of Tunnel = 2,280m

Number of Evacuation Adit	3
Number of Personnel Adit	2
Total	**5**

10.9.4 Structure

(1) Bridge

Total numbers of bridges are as follows;

Section	No. of Bridges			Length (m)	No. of Overpass Bridges
	PSCG	PC-Box	Total		
Section-I	9	1	10	1,206	2
Section-II	14	0	14	1,806	4
Section-III	20	1	21	2,119	6
Total	**43**	**2**	**45**	**5,131**	**12**

Source: JICA Study Team

(2) Culvert

Total numbers of culverts are as follows;

Number of Culverts			
Section	Pipe Culvert	Box culvert for River/Water	Box culvert for Crossing Road
Section-I	19	16	0
Section-II	39	16	3
Section-III	24	8	2
Total	**82**	**40**	**5**

Source: JICA Study Team

CHAPTER 11
PROJECT COST ESTIMATE

(Confidential)

CHAPTER 12
ECONOMIC EVALUATION

12.1 METHODOLOGY

The economic analysis shall be determined whether the construction and operation of the proposed project will be feasible based on the benefits and costs to be derived from the project. The transport projects such as Davao City Bypass can play a very important role in strengthen of the economic growth. It is required however, that the project must be economically viable, satisfying the government-prescribed hurdle rates.

Annual economic cost and benefits shall be estimated under “with project” and “without project” case. The difference in economic costs and benefits in both cases shall be attributed to the project and subjected to economic feasibility measurement. The economic feasibility of the project shall be indicated by the economic internal rate of return (EIRR), benefit-cost ratio (B/C), and net present value (NPV) at an assumed discount rate of 15%, which is acceptable social discount rate for economic appraisal of public investment projects in the country. The hurdle rates for economic feasibility are the following: EIRR $\geq$ 15%, B/C $\geq$ 1.0, and NPV $\geq$ 0. Sensitivity of the project arising from adverse changes in costs and benefits shall be examined to establish the capacity of the project to exhibit economic feasibility under these cases.

(1) General Work Flow of Economic Evaluation

Figure 12.1-1 shows the work flow of economic evaluation.

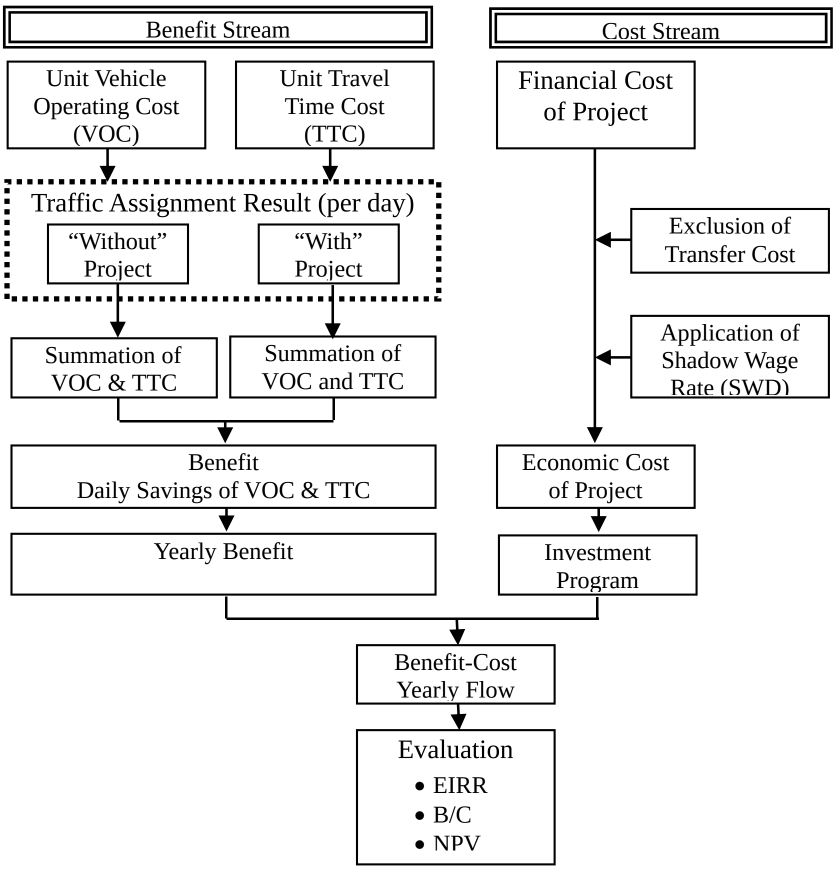


FIGURE 12.1-1 WORK FLOW OF ECONOMIC EVALUATION

(2) Indicators of Economic Evaluation

Economic costs and benefits throughout the project life periods are compared by a discount cash flow analysis. The discount rate (hereinafter referred to as "DR") is at 15%, which is widely used in Philippines as a social discount rate. For economic evaluation, three indicators are calculated: Economic Internal Rate of Return (hereinafter referred to as "EIRR"), Benefit/Cost Ratio (hereinafter referred to as "B/C") and Net Present Value (hereinafter referred to as "NPV"). In addition, the economic life is assumed to be 30 years, taking into account future rapid growth and changes of socioeconomic conditions. Therefore, the Pro-forma cash flow of a project evaluation will be prepared for 2014-2049. They are defined as **Table 12.1-1**.

TABLE 12.1-1 INDICATORS OF ECONOMIC EVALUATION

No.	Indicators	Calculation Formula or Value
1	Discount rate (DR)	15% in Philippines as a social discount rate
2	Economic Internal Rate of Return (EIRR)	r satisfying: *B*: benefit, *C*: Cost $\sum \frac{B_n}{(1+r)^n} = \sum \frac{C_n}{(1+r)^n}$
3	Benefit/Cost Ratio (B/C)	$\sum \frac{B_n}{(1+DR)^n} \div \sum \frac{C_n}{(1+DR)_n}$
4	Net Present Value (NPV)	$\sum \frac{B_n - C_n}{(1+DR)^n}$
5	Pro-forma cash flow of a project evaluation	Period for 2012-2049

Source: JICA Study Team

12.2 ECONOMIC COST OF THE PROJECT

(CONFIDENTIAL)

12.3 ECONOMIC BENEFIT OF THE PROJECT

Economic benefits are calculated according to multiplied the estimated traffic volumes and unit Vehicle Operating Cost (VOC) /Travel Time Cost (TTC) respectively for each case, and the amount of 'without' case minus 'with' case is considered as the benefit provided by the project.

(1) Unit Vehicle Operating Cost (VOC) and Unit Travel Time Cost (TTC)

1) Unit Vehicle Operating Cost (VOC)

The VOC per unit distance is estimated by type of vehicle being composed of the following components; they are a) fuel cost, b) oil cost, c) tire cost, d) spare parts cost, e) depreciation cost, f) capital opportunity cost and g) crew and overhead cost. The type of vehicles is motor-tricycle, car, van, Jeepney, bus and truck.

The Department of Public Works and Highways (DPWH) has been periodically updating VOC data in order to use as input to the HDM Model for the appraisal of highway development and maintenance projects. There are the detailed data of VOC in 2008 (see **Table 12.3-1**), therefore, these data are revised and updated in accordance with the GDP Growth Rate of 5.5% . They are summarized in **Table 12.3-2**.

TABLE 12.3-1 UNIT VOC BY VEHICLE TYPE IN 2008

(Pesos per veh-km)

Speed (km/h)	1 Motor-Tricycle	2 Car	3 Jeepney	4 Goods Utility	5 Small Bus	6 Large Bus	7 Rigid Truck 2ax	8 Rigid Truck 3ax	9 Semi-Trailer 4ax	10 Semi-Trailer 5ax
20	3.32	12.33	9.54	10.85	23.81	33.37	23.17	37.71	41.40	43.79
30	2.78	10.51	8.09	9.06	20.31	28.11	20.02	32.50	36.37	38.73
40	2.43	9.19	7.13	7.83	17.78	24.40	17.89	29.06	33.26	35.63
50	2.32	8.53	6.75	7.31	16.53	22.66	17.01	27.86	32.46	34.86
60	2.35	8.22	6.72	7.18	15.96	22.00	16.76	27.85	32.79	35.13
70	2.46	8.14	6.91	7.32	15.79	22.04	16.83	28.51	33.55	35.78
80	2.48	8.21	7.24	7.61	15.83	22.55	17.06	29.45	34.52	36.69
90	2.48	8.37	7.63	7.97	15.95	22.57	17.35	29.45	35.58	37.73
100	2.48	8.58	8.00	8.32	16.10	22.57	17.51	29.45	36.04	38.19
110	2.48	8.78	8.30	8.59	16.22	22.57	17.51	29.45	36.04	38.19
120	2.48	8.83	8.52	8.78	16.30	22.57	17.51	29.45	36.04	38.19

Source: DPWH

TABLE 12.3-2 UNIT VOC BY VEHICLE TYPE IN 2014

(Pesos per veh-km)

Speed (km/h)	1 Motor-Tricycle	2 Car	3 Jeepney	4 Goods Utility	5 Small Bus	6 Large Bus	7 Rigid Truck 2Axle	8 Rigid Truck 3Axle	9 Semi-Trailer 4Axle	10 Semi-Trailer 5Axle
20	20	4.58	17.01	13.16	14.96	32.83	46.01	31.95	52.00	57.09
50	30	3.83	14.49	11.16	12.49	28.00	38.77	27.60	44.81	50.15
80	40	3.35	12.67	9.83	10.80	24.52	33.65	24.66	40.07	45.85
90	50	3.20	11.76	9.31	10.08	22.79	31.24	23.45	38.41	44.76
100	60	3.23	11.33	9.26	9.91	22.00	30.33	23.11	38.40	45.21

Source: DPWH, JICA Study Team

The VOC saving in whole road network will be calculated according to multiplied the estimated traffic volumes and unit VOC. The unit VOC by type of vehicles will be corresponded to the four (4) vehicle types of estimated traffic volume such as 1) Passenger Car, 2) Jeepney, 3) Large Bus and 4) Truck. The VOC of truck types will be converted by weighted average of vehicle composition. The unit VOC cost by type of vehicles by vehicle speed is shown in **Table 12.3-3.**

TABLE 12.3-3 UNIT VOC BY FOUR (4) VEHICLE TYPES IN 2014

Peso/km/veh

Speed (km/hr)	Passenger Car	Jeepney	Bus	Truck
20	17.01	13.16	46.01	42.12
30	14.49	11.16	38.77	36.49
40	12.67	9.83	33.65	32.79
50	11.76	9.31	31.24	31.46
60	11.33	9.26	30.33	31.35

Source: DPWH, JICA Study Team

2) Unit Travel Time Cost (TTC)

The Travel Time Cost (TTC) is normally calculated based on the average labor productivity in the Philippines. The basic costs for TTC by type of passenger were obtained also from the DPWH. The values are 2014 price level. In the derivation of the TTC, the average income, employment and the gross national product were used as the basis to calculate for the working time and non-working time per person-hour for representative vehicle type and thence estimate for the passenger time cost per person.

Basically, reduction in travel time is the main component in the derivation of the TTC saving. The annual savings was calculated as the difference in travel time between the base road network and with Davao City Bypass road network. Travel time as estimated in the model is the result of the changes in traffic volume caused changes in the congestion level brought by diversion of part of traffic to a more convenient route in the road network. The unit TTC of vehicles will also be corresponded to the four (4) vehicle types of estimated traffic volume such as 1) Passenger Car, 2) Jeepney, 3) Large Bus and 4) Truck. The TTC of truck types will be converted by weighted average of vehicle composition. The unit TTC cost by type of vehicles in year 2014 which were updated based on the GDP growth rate of 5.5%, is shown in **Table 12.3-5.**

TABLE 12.3-4 UNIT TRAVEL TIME COST IN 2008

Peso/min/veh.

1. Motorcycle/ Tricycle	2. Passenger Car	3. Jeepney	4. Goods Utility	5. Small Bus	6. Large Bus	7. Rigid Truck 2axle	8. Rigid Truck 3axle	9. Rigid Truck 4axle	10. Rigid Truck 5axle
1.37	6.81	7.44	2.57	12.69	27.82	1.02	1.46	2.10	2.10

Source: DPWH

TABLE 12.3-5 UNIT TRAVEL TIME COST IN 2014

Peso/min/veh.

Vehicle Type	2014
Passenger Car	9.39
Jeepney	10.26
Bus	38.36
Truck	1.84

Source: JICA Study Team

(2) Estimation of Economic Benefit (VOC and TTC Saving)

Based on the unit VOC by vehicle type by vehicle speed and the total vehicle-km, daily VOC saving by year will be estimated. The daily TTC saving by year also will be estimated based on the unit TTC by vehicle type and the total vehicle-hour as shown in **Table 12.3-6**.

TABLE 12.3-6 ECONOMIC BENEFIT

Year	Economic Benefit (1,000 Peso/day)		
	VOC	TTC	Total
2018	813	1,954	2,767
2023	671	2,402	3,074
2033 (4-lane)	1,112	3,739	4,851

Source: JICA Study Team

(3) Other Economic Benefits

With the increasing congestion of the existing road, the greater is the likelihood of the occurrence of the accidents due to conflicts between pedestrian and vehicle. It is anticipated that with the project, accidents happening could be avoided. In this Study, however, benefit from possible reduction of road accident is not considered since there is no acceptable value assigned to traffic accidents in the country.

12.4 RESULTS OF ECONOMIC ANALYSIS

The performance at **Table 12.4-1** of the project based on indicators of economic feasibility is:

<Year 2014, Philippine Peso Base>

EIRR	18.1%
B/C	1.25
NPV (Million Peso @ i=15%)	2,096.5

The economic costs and benefits of the project generated a positive NPV and on EIRR that is much higher than the government prescribed hurdle rate (15%). These values indicate that the project is economically viable.

TABLE 12.4-1 COST-BENEFIT STREAM

(CONFIDENTIAL)

12.5 PROJECT SENSITIVITY

The Project Sensitivity to the identified risks is shown in **Table 12.5-1**.

TABLE 12.5-1 PROJECT SENSITIVITY

	Base	Cost plus 10%	Cost plus 20%
Base	18.1%	16.7%	15.6%
Benefit less 10%	16.6%	15.3%	14.2%
Benefit less 20%	15.0%	13.8%	12.8%

In order to hurdle the minimum criteria EIRR=15%, cost up and/or benefit down should be below condition.

- Cost Plus 25%
- Benefit less 20%
- Cost plus 11% and Benefit less 11%

CHAPTER 13
ENVIRONMENTAL CONSIDERATIONS

In this chapter, summarized information and result of analysis is described based on relevant Philippines laws and JICA Guidelines for Environmental and Social Considerations (April, 2010). Detailed information is contained in the main Environmental Impact Statement (EIS) Report.

13.1 BASELINE OF THE ENVIRONMENTAL AND SOCIAL CONDITION

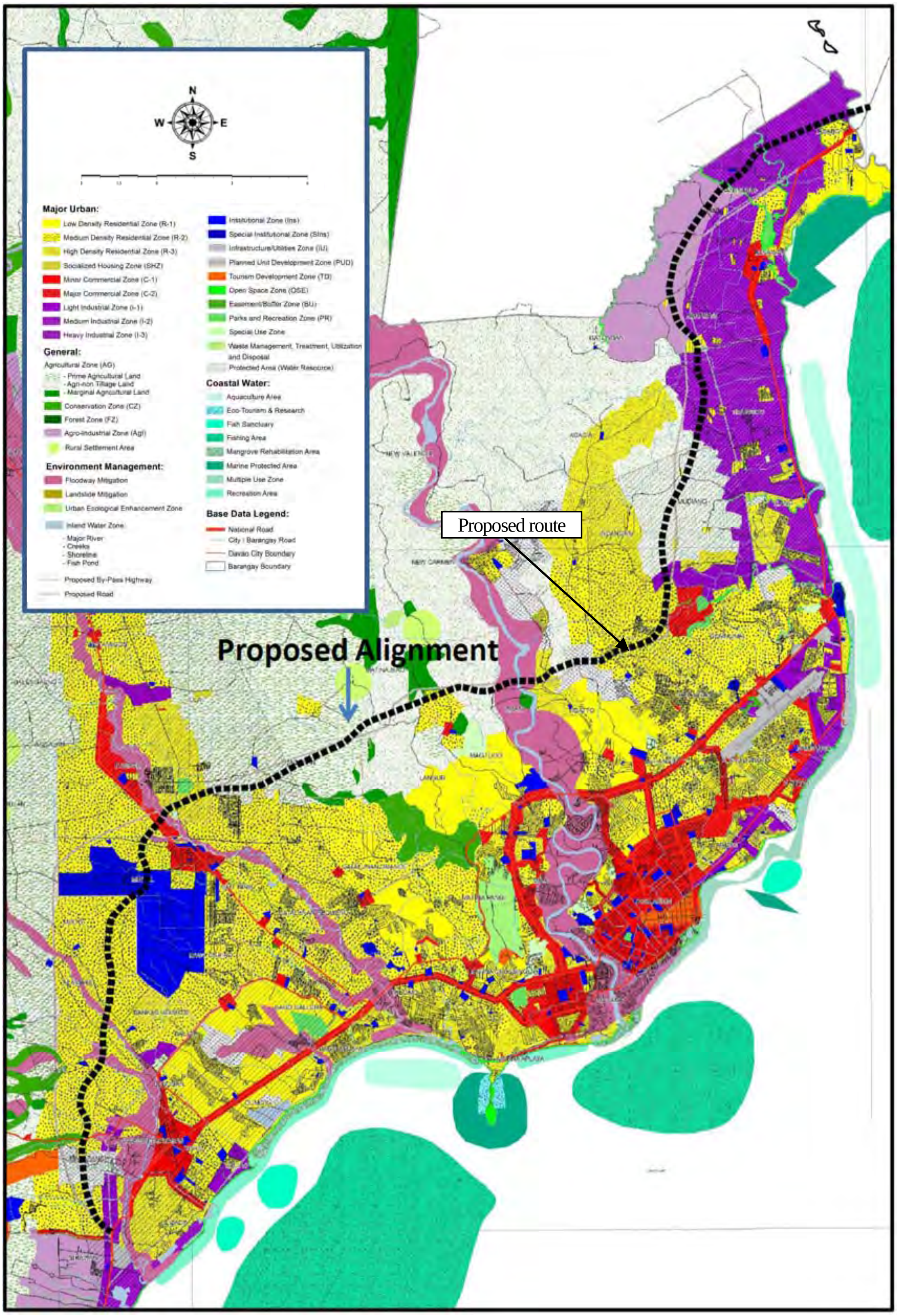
Based on the existing information, environmental and social condition around the project site is reviewed in the following sections. The name of articles and items are in accordance with relevant Philippines regulations (Memorandum Circular 2010 No.14).

13.1.1 Land

(1) Land use

The land use on the planned area is used for mainly agricultural area such as palm trees and secondly woodland. Residential, industrial area and native bush & woodland are slightly distributed on the planned alignment in accordance with satellite image.

On the other hand, the alignment is passing through planned industrial zone (I-1, I-2 and I-3), medium density residential zone (R-2) and agricultural & pasture land zone as the result of minimization of impact on high density residential area. The mentioned land use map is shown in **Figure 13.1-1.**

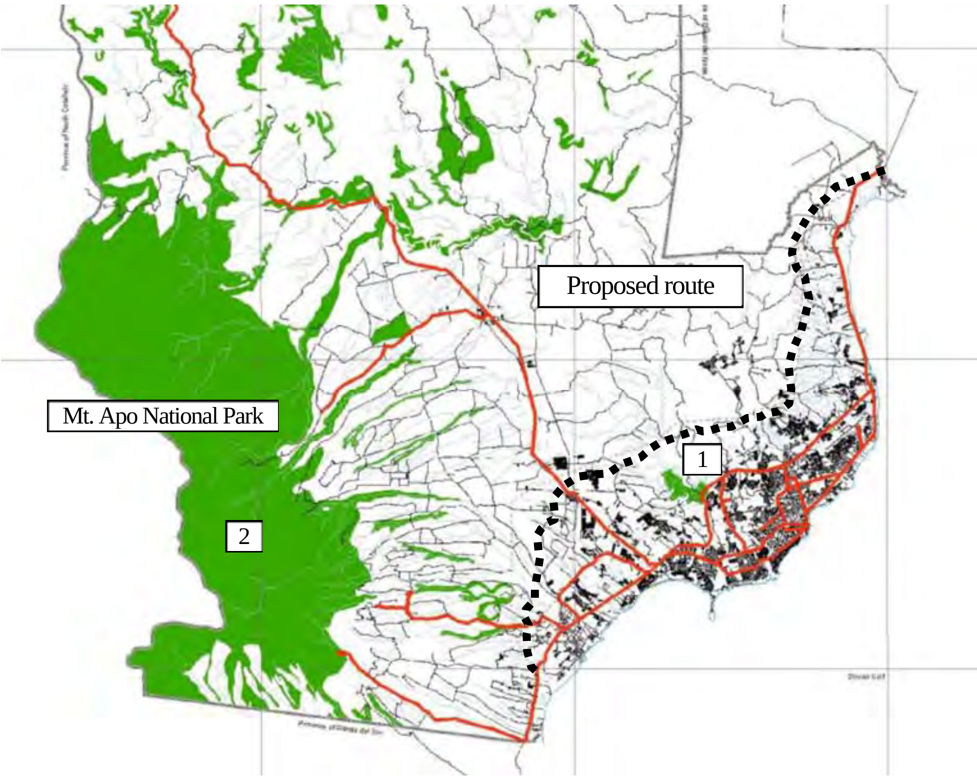


Source: Davao City 2013 (Comprehensive Zoning Ordinance of Davao City 2013-2022)

FIGURE 13.1-1 DETAILED URBAN ZONING MAP (2013-2022)

(2) Protected area

These conservation zones are declared by laws as national parks, watershed reserves, wildlife preserves and sanctuaries. The alignment has been set up with avoiding such designated protected areas as shown in **Figure 13.1-2.**



Source: CLUP Davao City Volume2 Zoning Ordinance 2013-2022

FIGURE 13.1-2 PROTECTED AREA AROUND THE PROJECT SITE

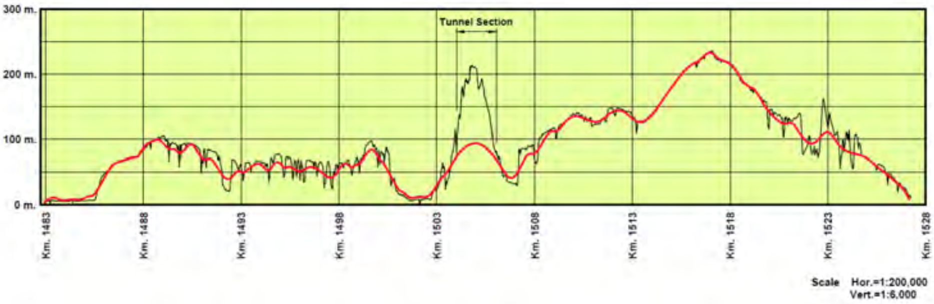
The distributed protected areas are 1) Malagos Watershed Reservation and 2) Mt. Apo National Park around project area. These status and outlines are shown in **TABLE 13.1.1 1**.

TABLE 13.1.1-1 DEFINITION OF CONSERVATION ZONE

Location	Name of Conservation Zone	Relevant laws and regulation	Description
1) Malagos, Baguio District	Malagos Watershed Reservation	Presidential Proclamation 2146: Proclaiming Certain Areas and Types of Projects as Environmentally Critical and Within the Scope of the Environmental Impact Statement System Established under Presidential Decree No. 1586. (December 14, 1981)	This area is declared as Conservation area of Environmental Critical Area under the category of Watershed Forest Reserve with an area of 235 hectares. It is proclaimed as no. 612 on August 31, 1933. Aforementioned proclamation aims to attain and maintain a rational and orderly balance between socio-economic growth and environmental conservation and protection.
2) Kidapawan, Makilala, Magpet, Cotabato; Sta. Cruz, Bansalan, Digos City and Davao City, Davao del Sur	Mt. Apo National Park	• Republic Act 7586 "National Integrated Protected Areas system Act of 1992." • Republic Act 9237 "Mount Apo Protected Area Act of 2003"	This area was declared as protected area under the category of natural park with an area of 54,974.87 hectares of protected area along with 9,078 hectares of buffer zone. On May 9, 1936, Mount Apo was proclaimed as a national park with Proclamation no. 59 by President Manuel L. Quezon, followed by Proclamation no. 35 of May 8, 1966 then Proclamation No. 882 of September 24, 1996. This area is targeted to be protected for the importance of cultural and ecological diversity and conservation of various resources.

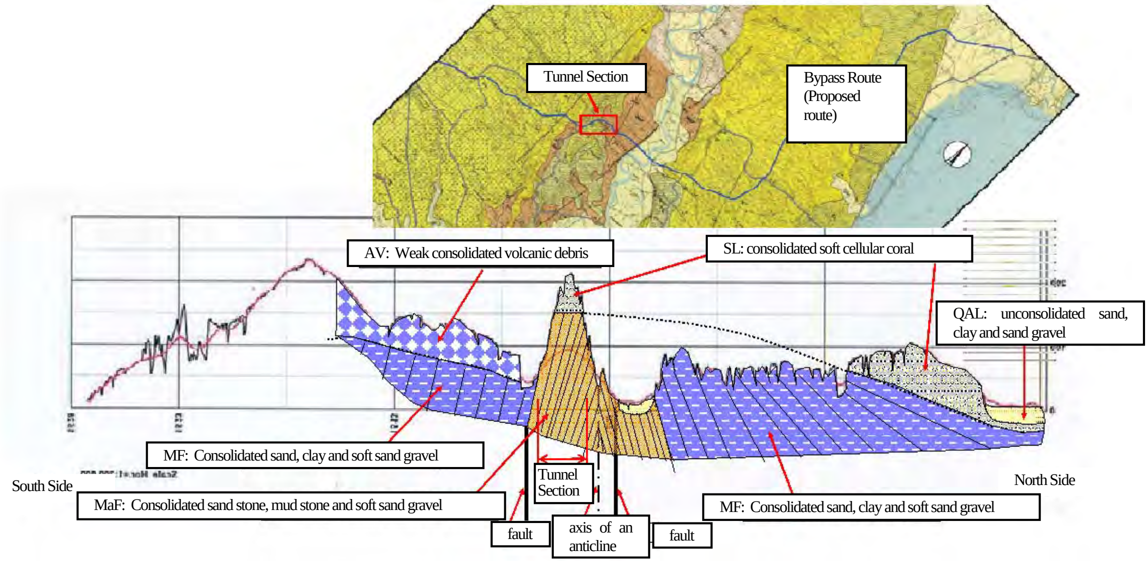
(3) Topography and Geology

The project site is located 2-10km east from shoreline. The route is passing through a mountainous area between some rivers, and the slope angle of tunnel section is approximately 20 degrees and the depth is more than 100m from the surface as shown in **Figure 13.1-3.** The geology consists of sedimentary rock and volcanic debris from Mt. Apo. as shown in **Figure 13.1-4**.



Source: JICA Survey Team

FIGURE 13.1-3 PROJECT LOCATION AND THE SURROUNDING TOPOGRAPHY



Source: JICA Survey Team

FIGURE 13.1-4 PROJECT LOCATION AND THE SURROUNDING GEOGRAPHY

(4) Hydrology

The nine watershed are recognized in Davao City as shown in **Figure 13.1-5.**. The alignment is passing through downstream area of 7 watersheds such as Lipadas, Talomo, Matina, Davao, Panacan, Bunawan and Lasang. The Talomo watershed areas are located in a part of Mt. Apo national park, thus most of production wells are distributed and concentrated in downstream of the area as shown in **Figure 13.1-6.** The alignment has been set up with avoiding such production wells area.

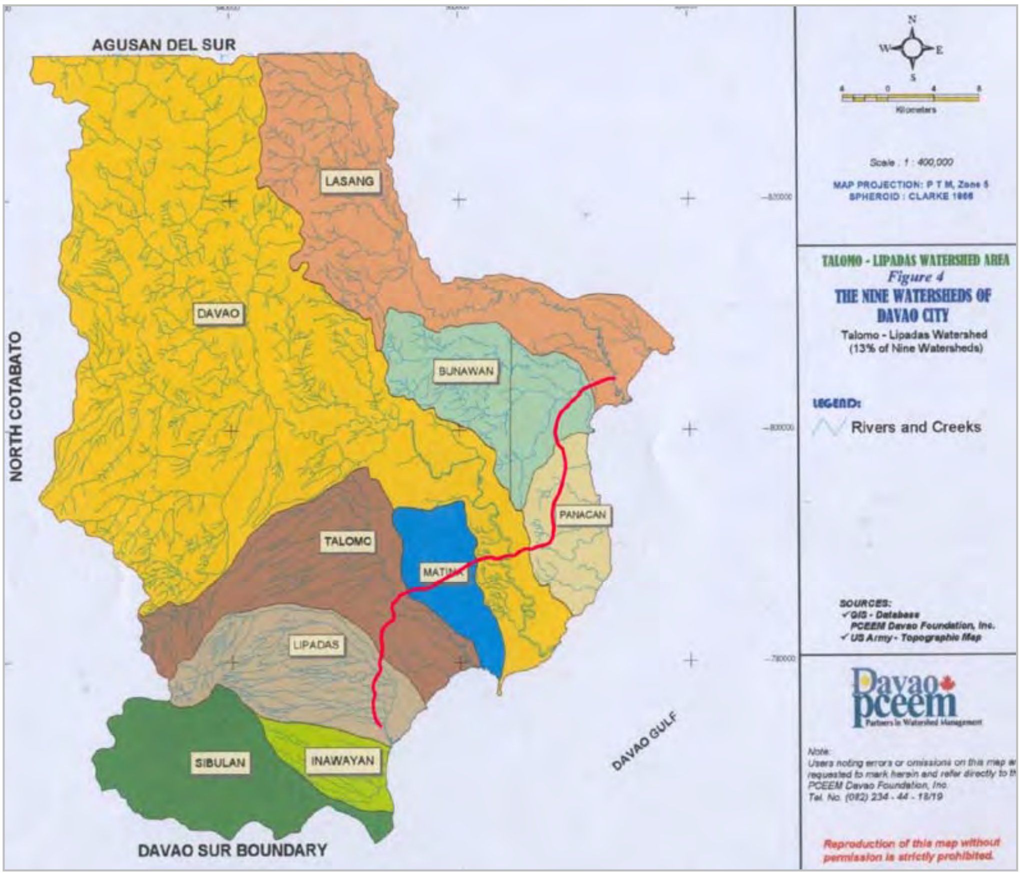


FIGURE 13.1-5 Watershed Area in Davao City
Source: Davao City Water District 2013

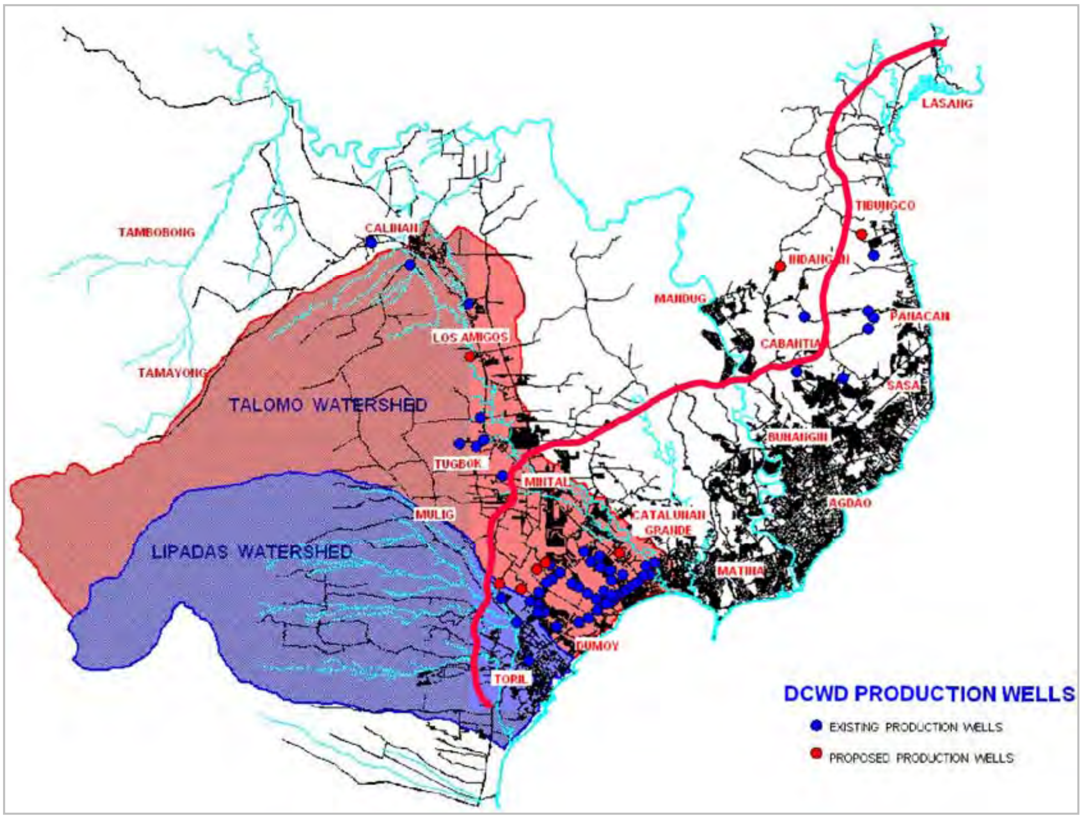


FIGURE 13.1-6 Production Well Location in Davao City
Source: Davao City Water District 2013

(5) Biology

General condition of the proposed route is passing through developed areas such as plantation farm land, open grass land and pasture land. Some areas are forest, however mostly are secondary forests for timber production. A protected area named Mt. Apo Natural Park is approximately 10km west of the project area as shown in **FIGURE 13.1 -2**. It's known Mt. Apo is home to one of the world's largest eagles: the critically endangered Philippine Eagle, the country's national bird. According to the Philippines Eagle Student Workbook (JICA), their major habitats are not distributed in the project area as shown in **FIGURE 13.1-7** . Accoriding to interview with Regional DENR Wildlife Section and the Philippine Eagule Fundation, idetified nesting and activitiy area of the eagle is in the Mt. Apo national park area, not project area.

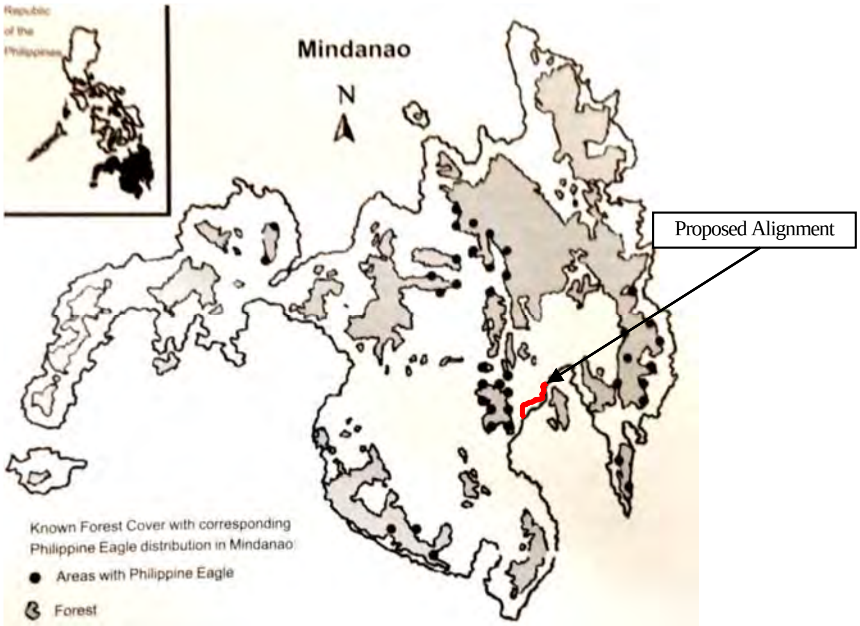


FIGURE 13.1-7 PHILIPPINE EAGLE DISTRIBUTION IN MINDANAO

Source: JICA (the Philippines Eagle Student Workbook)

13.1.2 People

(1) Population and Economy

The road alignment is located in Davao City and Panabo City, passing through 3 Districts in Davao and 26 Barangays in Davao and Panabo. The population is 1,449 thousand and density is 593 persons / km^2 in Davao City, 2010 as shown in **TABLE 13.1.2 1**. Integrated population where the alignment is located is approximately 250 thousand persons on 26 Barangays as shown in **TABLE 13.1.2-2.** As other economic indicators are shown below, estimated income is small comparing with Metro Manila and the rate of unemployment is lower than national average.

TABLE 13.1.2-1 SOCIO-ECONOMIC SITUATION IN THE PROJECT AREA (DAVAO CITY, PANABO CITY and DAVAO REGION)

Item		Value	Year	Remarks
Population (Persons x 1,000)	Davao City	1,449.3	2010	Annual Increase rate for 10 years 2.36% (2000/1147.1-2010/1449.3)
	Panabo City	174.4	2010	Annual Increase rate for 10 years 2.67% (2000/134.0-2010/174.4)
Average Income (Peso/family/year)	Davao Region (Region XI)	166,000	2009	Manila: 354,645 Peso/family/year (2009)

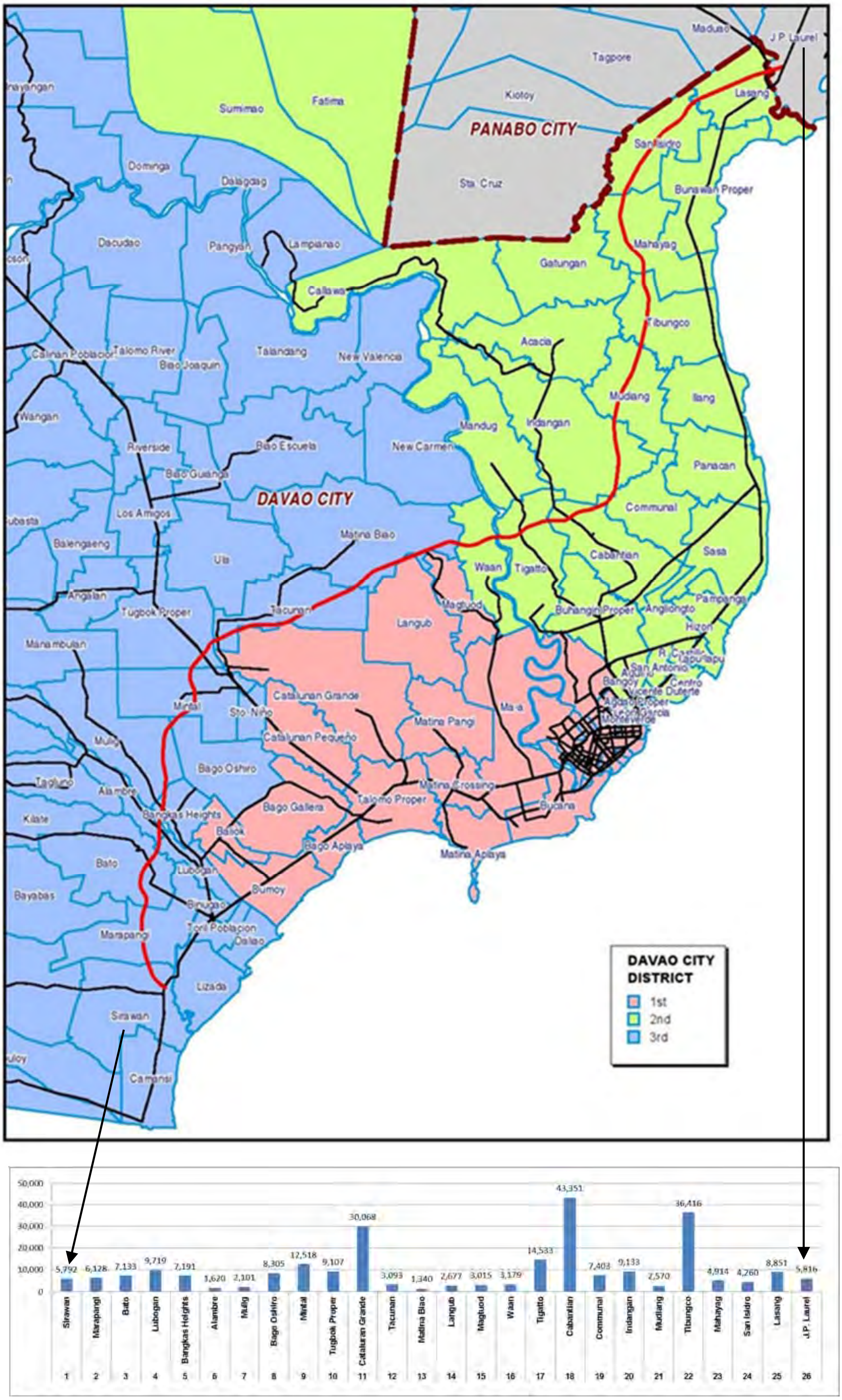
Item		Value	Year	Remarks
Average Expenditure (peso/family/year)	Davao Region (Region XI)	142,000	2009	Manila: 321,197 Peso/family/year (2009)
Unemployment Rate (%)	Davao Region (Region XI)	4.6	2011	National average : 6.4% (2011)
Annual Poverty threshold (Peso/person/year)	Davao City	17,040	2009	Poverty incidence (2009) Davao City 13.2%, Davao region 31.3%
	Panabo City	-	-	
Area (km2)	Davao City	2,444km2	2010	-
	Panabo City	251.23km2	2010	
Population Density (Persons/km2)	Davao City	593	2010	
	Panabo City	694	2010	

Source: National Statistic Office

TABLE 13.1.2-2 POPULATION OF BARANGAYS ON THE PROPOSED ROUTE

City	District	Sub District	Barangay	Population
Davao	First	Talomo	Cataluran Gr	30,068
			Langub	2,677
			Magtuod	3,015
	Second	Bunawan	Lasang	8,851
			San Isidro	4,260
			Mahayag	4,914
			Tibungco	36,416
			Mudiang	2,570
		Buhangin	Indangan	9,133
			Communal	7,403
			Cabantian	43,351
			Tigatto	14,533
			Waan	3,179
	Third	Tugbok	Matina Biao	1,340
			Tacunan	3,093
			Tugbok Prop	9,107
			Mintal	12,518
			Bago Oshiro	8,305
		Toril	Mulig	2,101
			Alambre	1,620
			Bangkas Hei	7,191
			Lubogan	9,719
			Bato	7,133
			Marapangi	6,128
			Sirawan	5,792
Panabo			J.P. Laurel	5,816
				250,233

Source: National Statistic Office



Source: JICA (National Statistics Office 2012)

FIGURE 13.1-8 OPULATION PER BARANGAY

(2) Traffic situation

Existing trunk roads in the city are mainly Pan-Philippine Highway which plays a part of bypass in the business district of Davao City, and Davao-Bukidnon Road which is connecting with the western cities such as Cagayan de Oro City. Other local roads are running from Pan-Philippines Highway to the west direction on ridge line. Traffic volume of the trunk road is shown in **Figure 6.1-1** and **Figure 6.1-2.**

Traffic congestion of roads in the urban center is chronic and travel speed of most road are less than 20km/hr as shown in **Figure 6.1-32.**

13.2 LEGISLATION AND INSTITUTION FOR ENVIRONMENTAL AND SOCIAL CONSIDERATIONS

13.2.1 Legislation for Environmental Considerations

Major laws regarding environment is shown in **TABLE 13.2.1-1**. Environmental related laws in the Philippines are composed of under the Presidential Decree (PD) No.1151 as environmental policy and PD No. 1152 as environmental regulation in relation to the national policy and regulation.

TABLE 13.2.1-1 PHILIPPINE'S MAJOR ENVIRONMENTAL LAWS

Title	Contents
Presidential Decree (PD)No.1151	Environmental policy
Presidential Code (PD)No. 1152	Environmental regulation

Major environmental laws are made for natural resources, protection of wild life and bio-diversity, forest resources, mining, coastal and marine, ambient air, water quality, waste and disposal, land use and resettlement, conservation of historical and cultural assets, environmental assessment, and national integrated protected area system. Major environmental related laws and decrees are summarized in **TABLE 13.2- 2**.

TABLE 13.2.1-2 PHILIPPINE'S ENVIRONMENTAL LAWS AND DECREE BY CATEGORY

Category	Title	Outline
Natural Resources	Constitution Article 12./Clause 2.	Investigation of natural resources, development use
	Presidential Decree (PD)/ No.1198	Protection of natural environment
Protection of wildlife and bio diversity	Republic Decree No. 826	Preservation of Natural parks and establishment of wildlife protection committee
	Republic Decree No.1086 (1954)	Prohibition of capture of Mindoro buffalo (Tamaraw)
	Republic Decree No.6147	Preservation of Monkey Eating Eagle
	Statement No. 2141	Preservation of wilderness region
	Administrative order	No.243(1970) Prohibition of slaughter for buffalo
Forest resources	Presidential Decree (PD) No.209	Encourage of common forest project
	Presidential Decree (PD) No. 277	Encourage of report on offender against forest law
	Presidential Decree (PD) No. 278	Procedural regulation on development application for forest resources and forest land development use
	Presidential Decree (PD) No. 331 (1973)	Sustainable forest development Forest resources
	Presidential Decree (PD) No. 389	Regulation on forest recovery
	Presidential Decree (PD) No. 705 (1975)	Amendment of regulation on forest recovery
	Presidential Decree (PD) No. 865	Export of lumber (selective deforestation)
	Presidential Decree (PD) No. 953	Request of forestation
	Presidential Decree (PD) No. 1153	Decree of forestation
	DNR DecreeNo.78(1987)	Regulation on permission range for felling and collection of oak, other hard wood
	DNR Decree No.79 (1987)	Establishment of foundation of forest regeneration
	DNR Decree No.79 (1987)	Establishment of foundation of forest regeneration

Category	Title	Outline
	DNR memorandum No.8 (1986)	Full prohibition of log export
	Notification No. 818	Diminution of forest
	Forest development bureau circular No. 13 (1986)	Full prohibition of land possession within mangrove area, river area, preservation area, wilderness area, National park, wildlife reserve, experimental forest and etc.
Mining	Presidential Decree (PD) No.1251	Prospect mining
	Presidential Decree (PD) No.463 (1974)	Mining resource development Decree
	Presidential Decree (PD) No.1189 (1979)	Land use of ex-mining site for compensation of the land owner
Coastal marine	Presidential Decree (PD) No.600 (1974)	Prevention of marine pollution
	Presidential Decree (PD) No. 602 (1974)	Establishment for oil pollution management center
	Presidential Decree (PD) No. 979	Prevention of ocean pollution
Ambient air	Republic law No. 3931	Establishment of National air, water pollution control committee, definition of pollution and penalty
	Presidential Decree (PD) No.1181	Air pollution regulation on incidence origin of travelling
	Presidential Decree (PD) No.1160	Barangay captain Community leader on implementation of law on prevention of public nuisance
	Circulation No. 247	Appointment of highway patrol guard
	Circulation No 551	Equipment of prevention devices of motor vehicles
Water quality	Republic law No.4850	Establishment of Laguna Lake development Bureau
	Republic law No.3931	Establishment of National committee for ambient air pollution management
	Presidential Decree (PD) No.600	Establishment of Philippine coastal guard, measure for marine pollution
	Presidential Decree (PD) No.1252	Establishment of foundation for treatment of mining discharge water
	Presidential Decree (PD) No.602	Establishment of National oil pollution management center
	DENR Decree No. 34	Classification of water and use
	DENR Decree No. 35	Regulation on discharge water for Industrial and urban drainage
Waste disposal	Presidential Decree (PD) No. 825 (1975)	Penalty regulation on illegal dump of disposal, dirt and other wastes
	Presidential Decree (PD) No. 826 (1975)	Regulation on treatment responsibility of solid and liquid wastes by local government
	Presidential Decree (PD) No.1152 (1977)	Regulation on treatment method and treatment management for wastes
	Republic Act (RA) 6969 (1990)	An Act to Control Toxic Substances and Hazardous and Nuclear Wastes, Providing Penalties for Violations thereof, and for their Purposes
	DAO 36 Series of 2004 (DAO 04-36)	DAO 04-36 is a procedural manual of DAO 92-29, a comprehensive documentation on the legal and technical requirements of hazardous waste management
	DAO 98-50	Adopting the Landfill Site Identification and Screening Criteria for Municipal Solid Waste Disposal Facilities
	DAO 98-49	Technical Guidelines for Municipal Solid Waste Management
	RA 9003	Ecological and Solid Waste Management Act
	DAO 01-34	Implementing Rules and Regulations (IRR) of RA 9003
	AO 93-90	Creating a Project Management Office on Solid Waste Management (PTWFM) under the Presidential Task Force on Waste Management
Land use and resettlement	Constitution Article 13	Establishment of human protective committee and their responsibility
	DPWH Decree No.65	Land use procedure for public project and expressway project

Category	Title	Outline
	DPWH Decree No.120 (1988)	Compensation of private land for DPWH project
	DPWH Decree No.234 (1990)	Amendment of compensation of private land for DPWH project
	Revised administrative code No. 64	Competence of house of justice on private land acquisition by the government
	DPWH Decree No.65 (1983)	Guideline for land use and right of way
	Presidential Decree (PD)No. 1517	Designation of reserve area at reorganization of urban land use
	Senate article No. 328	Decree of temporally prohibition for removal of displaced persons
	Republic Act 7279 (Urban Development and Housing Act of 1992)	An act to provide doe a comprehensive and continuing urban development and housing program, establish the mechanism for its implementation, and for other purpose; Procedure for removal of habituated peoples
Land acquisition	Republic Act 6389 (1971): The Agricultural Land Reform Code	The agricultural lessee shall be entitled to disturbance compensation equivalent to five times the average of the gross harvests on his landholding during the last five preceding calendar years
	Executive Order (1985)	Providing the procedures and guidelines for the expeditions acquisition by the government of private real properties or rights thereon for infrastructure and other government development projects
	Republic Act 8974 (2000)	An act to facilitate the acquisition of right-of-way, site or location for national government infrastructure project and for other purposes
Human rights	Executive Order NO.153 (2002)	Instituting the national drive to suppress and eradicate professional squatting and squatting syndicates; Amending E.O.178 (1999) and E.O. 128 (1993)
	Indigenous People's Rights Act (IPRA) of 1997	sets the conditions, requirements, and safeguards for plans, programs and projects affecting Indigenous Peoples (IPs)
	NCIP Administrative Order No. 1, Series of 2006	The procedure for obtaining the "Free and Prior Informed Consent" (FPIC) for affected communities
Conservation of historical cultural assets	Republic Decree No. 4365	Responsibility of National historic committee on authorization , restoration and maintenance for historical assets
	Republic Decree No.4346	Responsibility of protection and propulsion of maintenance for cultural assets within National museum
Environmental assessment	Presidential Decree (PD) No.1586	Environmental assessment system and administrative organization
	Presidential Proclamation No. 2146	3 Industrial sectors with large environmental impacts and 12 environmentally critical regions
National integrated protected area system	National integrated protected area system act (1992)	Review of National integrated protected area

Source: JICA Survey Team

The government of Philippine has been ratified international treaties, agreements, and protocols in relation to environmental and social consideration which are listed in **TABLE 13.2.1-3**.

TABLE 13.2.1-3 PHILIPPINE'S ENVIRONMENTAL AGREEMENT ON THE GLOBAL TREATY

Title	Year
Washington Treaty Convention on the international trade in endangered species of wild flora and fauna	(1981)
International tropical timber agreement	(1983)
United Nations convention on the law of the sea	(1984)
World heritage convention concerning the protection of the world cultural and natural heritage	(1985)
Montreal Protocol on substances that deplete the Ozone layer	(1991)
Vienna convention for the protection of the ozone layer	(1991)
Convention on biological diversity	(1993)
Basel convention on the control of trans-boundary movement of hazardous wastes and their disposal	(1993)
Ramsar convention on wetlands of international importance, especially as waterfowl habitat	(1994)
Framework convention on climate change	(1994)
Kyoto protocol	(1998)
Cartagena protocol on bio-safety to the convention on biological diversity	(2000)
Stockholm convention on persistent organic pollutants	(2001)

Source: JICA Survey Team

13.2.2 Philippines Environmental Impact Assessment System

In the Philippines, all private or public projects or activities which are envisaged to potentially have a negative impact on the environment are subject to environmental impact assessment (EIA) by Philippine Environmental Impact Statement System (PEISS). EIA is the preliminary analysis of the potential impacts of the project on the environment. Aware of the possible negative effects of the implementation of industrial and other activities, the Philippine government has instituted measures to encourage the use of EIA as a planning and decision making tool.

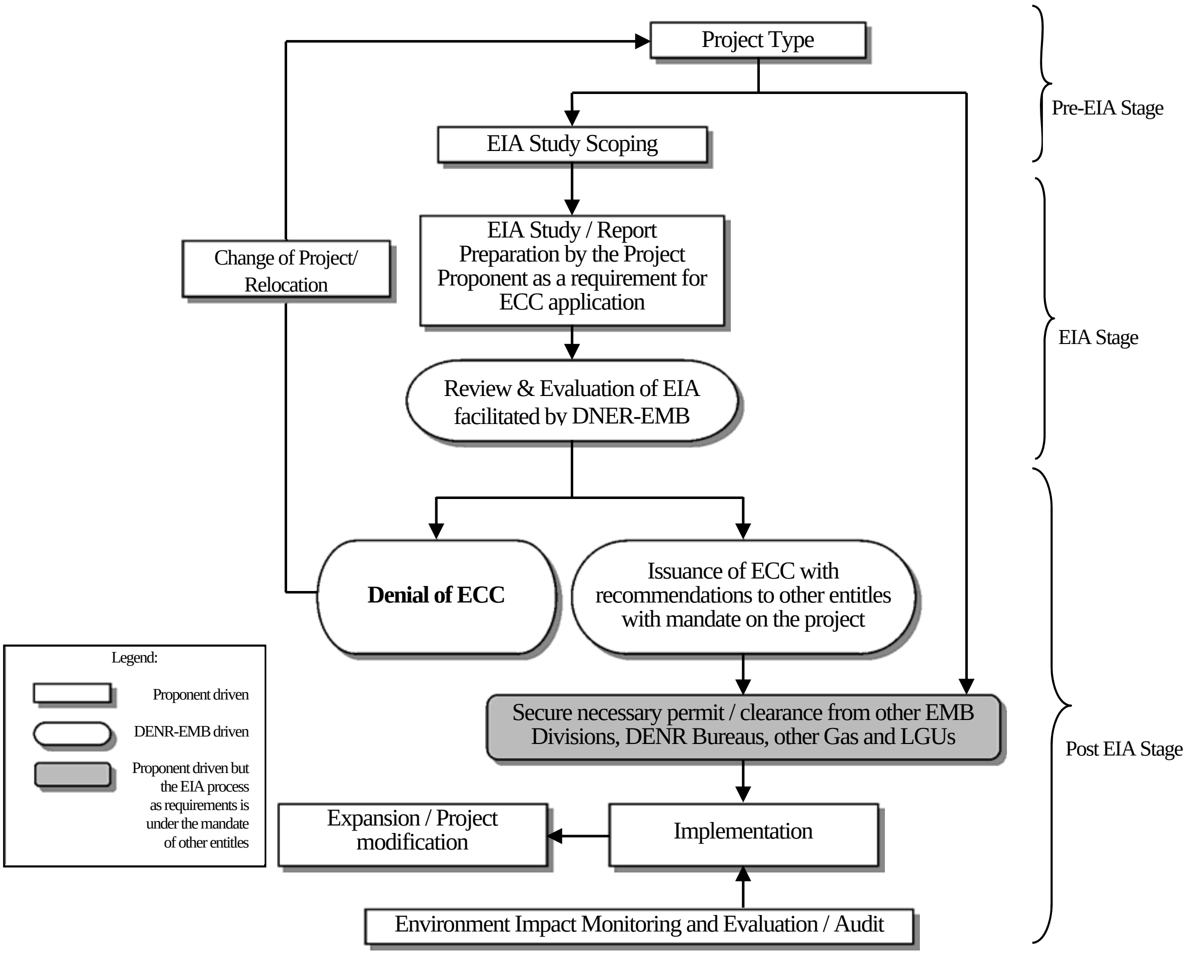
PEISS is a set of laws, regulations, administrative orders and guidelines concerned with Environmental Impact Assessment (EIA). **TABLE 13.2.2-1** shows some of the important laws and guidelines:

TABLE 13.2.2-1 PHILIPPINE'S LAWS AND REGULATIONS REGARDING EIA

Title	Outline
Environmental Impact Statement System (EISS), Presidential Decree No. 1586 (1978)	An act establishing and centralizing the Environmental Impact Statement (EIS) System under the National Environmental Protection Council (NEPC), which merged with the National Pollution Control Commission (NPCC) in June 1987 to become the Environmental Management Bureau (EMB).
Presidential Proclamation No. 2146 (1981) and No. 803 (1996)	It proclaims Environmentally Critical Projects (ECPs) to have significant impact on the quality of environment and Environmentally Critical Areas (ECAs) as environmentally fragile areas within the scope of the EIS System.
DAO 96-37 (revised to become DAO 92-21)	Devolved responsibility for EIS to the EMB-Regional Office and further strengthened the PEISS. Placed emphasis on promoting maximum public participation in EIA process to validate the social acceptability of the Project.
DENR Administrative Order No. 30 Series of 2003 (DAO 03-30)	Revised Procedural Manual (2007): Provides for implementation of rules and regulations of Presidential Decree No. 1586, establishing PEISS. Also, provided detailed definitions of technical terms and detailed information regarding procedures, related laws and regulations.

Source: JICA Survey Team

The procedures of EIA are shown in **FIGURE 13.2-1**. The process stage is categorized as: (1) pre-study stage (screening and scoping), (2) EIA study stage and (3) post-study stage (review, decision-making and monitoring).



Source: Revised Procedural Manual for DENR Administrative Order No.30 Series of 2003 (DAO 03-30)(2007)

FIGURE 13.2-1 FLOWCHART OF EIA

13.2.3 Screening of the Project

According to the Presidential Decree (PD) 1586 (1978), the EIA process covers project which have been originally declared as Environmentally Critical Projects (ECPs) or projects in Environmentally Critical Areas (ECAs) presumed to have significant impacts on the quality of the environment. On the other hand, non-covered projects are required environmental safeguard if deemed necessary by DENR. The project components are consisting of app. 45 km new road and more than 1km tunnel construction, and any ECAs such as declared national parks, designated watershed reserves and other areas in accordance with the Proclamation No. 2146 (1981) is not located in the project area, thus the project has been classified as Group-I-A which is required Environmental Impact Statement (EIS) and Environmental Compliance Certificates (ECCs) under Environmental Management Bureau Central Office. The criteria of ECPs are shown in **TABLE 13.2.3-1**.

TABLE 13.2.3-1 LIST OF ENVIRONMENTALLY CRITICAL PROJECTS (ECPS) FOR GROUP-I INFRASTRUCTURES

Project Type	Parameter	Requirements
Major Dams	Reservoir ≧25ha or ≧20 million m3	-Applied to; Single project -Required document EIS -Decision document ECC -Endorsers official Community organizer: EIAMD Chief/ EMB Director -Deciding Authority EMB Director / DENR secretary -Max time to grant ECC application 120 days
Major Reclamation	Projects ≧50ha	
Bridges and viaducts(elevated road), new construction	≧10km	
<u>Roads, new construction</u>	**≧20km** **≧10km with critical slope**	
<u>Tunnels and sub-grade roads and Railways</u>	**≧1km**	
Fuel Cell	≧100MW	
Gas-fired thermal power plants	≧50MW	
Geothermal facilities	≧50MW	
Hydropower facilities Impounding	≧20 million m3	
Other thermal power plants	≧30MW	

Source: Group I : Environmentally Critical Projects (ECPs) in both ECAs and Non-ECAs (Presidential Decree: No.2146 (1981) for Infrastructure projects

13.2.4 Gaps between Philippines and JICA's Guideline of EIA

Based on the principles for "EIA Reports for Category A Projects" requested by JICA Guideline, gaps between the Guideline and the legislation in Philippines reviewed in **TABLE 13.2.4-1 エラー! 参照元が見つかりません。**. Basically, the Philippines legislation deems to meet the policy of JICA's Guideline, thus Philippines EIA process is applicable on this project.

TABLE 13.2.4-1 GAPS BETWEEN JICA GUIDELINE AND THE PHILIPPINE LEGISLATION ON EIA

JICA Guideline (Appendix 2. EIA Reports for Category A Projects)	**Legislation of Philippine** (DENR Administrative Order No. 30 Series of 2003 (DAO 03-30))	**Gaps**	**Policy to fill up gaps in this Study**
1. When assessment procedures already exist in host countries, and projects are subject to such procedures, project proponents etc. must officially finish those procedures and obtain the approval of the government of the host country.	The project is required to prepare the EIA and obtain the environmental compliance certificates (ECCs) in accordance with Philippine laws	- (no difference)	Not required
2. EIA reports (which may be referred to differently in different systems) must be written in the official language or in a language widely used in the country in which the project is to be implemented. When explaining projects to local residents, written materials must be provided in a language and form understandable to them.	The order stipulates that EIA shall be written in the local dialect or mixed with the popularly known language of the host communities. In this case, English is recognized as a popularly known language in the project area.	-	Not required
3. EIA reports are required to be made available to the local residents of the country in which the project is to be implemented. The EIA reports are required to be available at all times for perusal by project stakeholders such as local residents and copying must be permitted.	The Proponent is required to give copies of the full EIA Report to the EMB Regional office host municipalities; copies of Executive Summary to the host barangays	-	Not required
4. In preparing EIA reports, consultations with stakeholders, such as local residents, must take place after sufficient information has been	The prescript public consultation is held with project affected persons and	-	Not required

JICA Guideline (Appendix 2. EIA Reports for Category A Projects)	Legislation of Philippine (DENR Administrative Order No. 30 Series of 2003 (DAO 03-30))	Gaps	Policy to fill up gaps in this Study
disclosed. Records of such consultations must be prepared.	other relevant agencies at scoping stage and draft EIA stage respectively after sufficient announcement of the meeting(s). Project outline is explained sufficiently prior to public consultation at scoping stage.		
5. Consultations with relevant stakeholders, such as local residents, should take place if necessary throughout the preparation and implementation stages of a project. Holding consultations is highly desirable, especially when the items to be considered in the EIA are being selected, and when the draft report is being prepared.	The prescript public consultation is held with project affected persons and other relevant agencies at scoping stage and draft EIA stage respectively after sufficient announcement of the meeting(s).	-	Not required

Source: The Survey Team

13.2.5 Roles of the Relevant Agencies

The Project is required of EIA and to secure ECC. Review and supervision of Philippine Environmental Impact Assessment System (PEISS) are conducted by the Environmental Management Bureau (EMB) under the Department of Environment and Natural Resources (DENR). The respective organization charts of EMB under DENR are shown below. Although Environmental Compliance Certificates (ECCs) is provided from Central office EMB Director and DENR Secretary, logistical arrangements in the project area such as arrangement of public consultation is conducted by the regional office environmental management bureau (RO EMB).

Roles of the relevant agencies of EIA of the project are show in **TABLE 13.2.5-1;**

TABLE 13.2.5-1 ROLES OF THE RELEVANT AGENCIES ON EIA OF THIS PROJECT

Relevant Agency		Roles
Department of Public Works and Highways (DPWH)		To proceed with the project of EIA procedure as the project proponent Detailed roles are show below; ✓ Holding of a meeting for Information, Education and Communication (IEC) ✓ Holding a meeting for Public Scoping for EIA ✓ Preparation & submission of project description for scoping (PDS) and Environmental Impact Statement (EIS) ✓ Payment of EIA review support fund ✓ Making the necessary logistical arrangements for public consultation ✓ Submission of final EIS and Environmental Performance Report and Management Plan (EPRMP)
Department of Environment and Natural Resources (DENR)	CO EMB	Responding to the application from the proponents, management of EIA review committee (EIARC) and the Director of EMB will issue the environmental compliance certificates (ECCs) for the port project Detailed roles are shown below; ✓ Facilitating of EIA Review Committee (EIARC) (scoping stage and substantive review stage) ✓ Scoping ✓ Procedural screening of EIS ✓ Conduct of public consultation ✓ Preparation of decision document ✓ Approval of ECCs from EMB Director / DENR Secretary

Relevant Agency		Roles
	RO EMB	Supporting of EIA process in the project area; ✓ Participation of public scoping facilitated by proponent of the project ✓ Making the necessary arrangements for EIARC site validation and public consultation

Source: Survey Team

13.3 ANALYSIS OF ALTERNATIVES

(1) Alignment Selection Criteria

The comparative analysis of alternatives was described in Chapter 7 and 9.The summary is shown below. The criteria for alignment selection are as follows;

- Bypass should be as closer to urban center as possible to attract more traffic.
- Minimize to affect existing houses/subdivisions and planned development.
- Alignment selected by the Business Case Study (BCS) is used as a base case.
- Connection with the intersecting roads which function as distributor shall be fully considered.
- Accessibility to ports and airports should be improved.

Figure 13.3-1 shows the selected alignment for the bypass road.

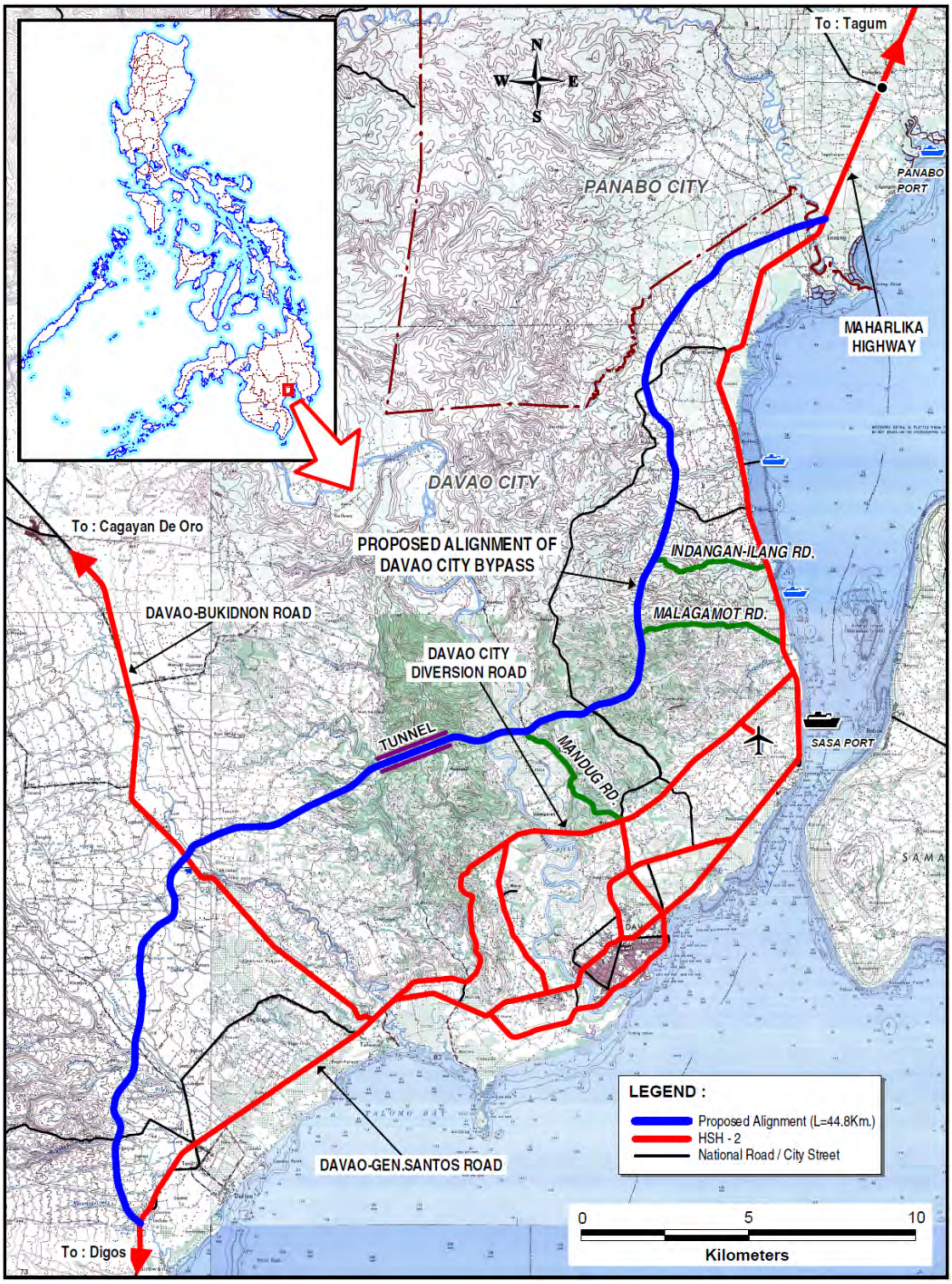


FIGURE 13.3-1 SELECTED ALIGNMENT OF DAVAO CITY BYPASS

(2) Evaluation Criteria

Alternative alignments are assessed by the number of items evaluated as “Good”, “Medium”, and “Bad”. An alternative which has more number of “Good” and lesser number of “Bad” is recommended.

- For the alternative which achieve the lowest value (or highest value) ⟶ Good (O)
- For the alternative within 10% difference compared to the lowest (or highest)) ⟶ Medium (△)
- For the alternative over 20% difference compared to the lowest (or highest) ⟶ Bad (X)

Figure 13.3-2 shows the alternative alignments for the bypass road.

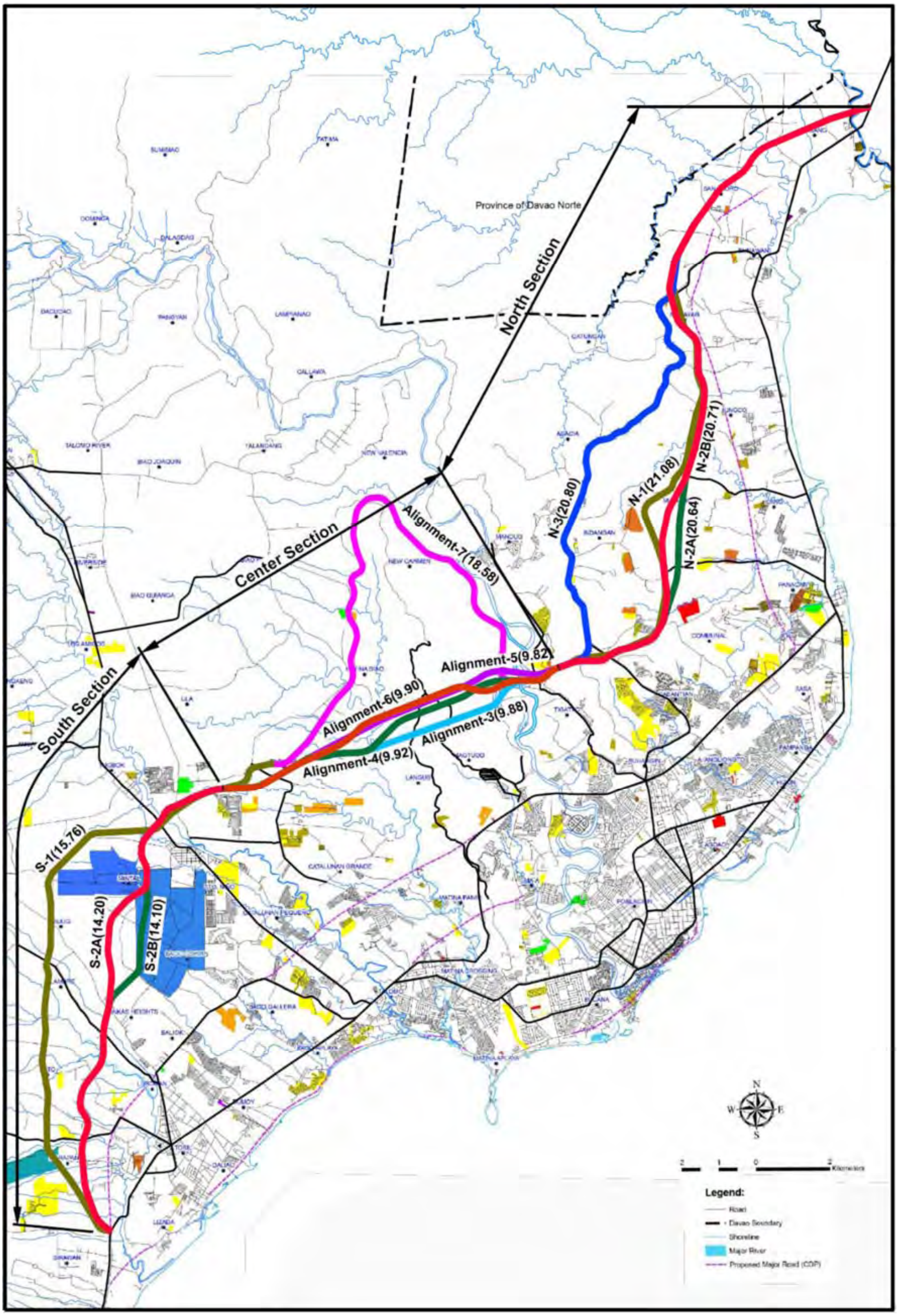


FIGURE 13.3-2 ALTERNATIVE ALIGNMENTS STUDIED FOR DAVAO CITY BYPASS

(3) Selected Alignment

Selected alignments for the South, Center and North Section are S-2A, Alignment-6, and N-2B respectively.

13.4 SCOPING

Scope of the EIA study for the project is discussed in this section. The environmental scoping is conducted based on an environmental reconnaissance by the JICA Survey Team from 20th September to 24th.

The result of scoping is indicated on the Leopold scoping matrix and reason tables as shown in **TABLE 13.4-1** and **TABLE 13.4-2**.

First of all, impact factors, impacted item and impact degree are shown on the following scoping matrix based on JICA's Guidelines. According to the scoping matrix, two (2) items such as No.3 (waste soil due to excavation) and No. 13 (Involuntary resettlement) are rated as "A" (significant impact) due to huge earth work volume and significant social impacts, fourteen (13) items are rated as "B" (Some impact is expected), six (6) item is rated as "C" (unknown impact is expected) and the others are rated as "D" (Few impacts are expected).

TABLE 13.4-1 DRAFT SCOPING MATRIX BASED ON JICA'S GUIDELINES AND PHILIPPINES ITEMS

		Affected Activities		**Overall Rating**	Pre/ During Construction Phase									Operation Phase		
	No	Impact Items (JICA)	(Philippines)		Land acquisition and Loss of properties	Change of Land use plan, Control of various activities by regulations for the construction	Reclamation of Wetland, etc.	Deforestation	Alteration to ground by cut land, filling, drilling, tunnel, etc	Operation of Construction Equipment and Vehicles	Construction of Roads, tollgates, parking lots, Access roads for bridges and other related facilities	Traffic Restriction in construction area	Influx of construction workers, construction of base camp	Increase of Through Traffic	Appearance/ Occupancy of Roads and related building structures including tunnel and embankment	Increasing influx of settlers
Pollution	1	Air Pollution	Air quality & noise	**B**	D	D	D	D	D	B	D	D	D	B	D	D
	2	Water pollution	Water quality	**B**	D	D	D	D	B	D	D	D	B	D	D	D
	3	Waste	Abandonment	**A**	D	D	D	A	A	D	D	D	D	D	D	D
	4	Soil contamination	Soil quality/fertility	**B**	D	D	D	D	B	D	D	D	D	D	D	D
	5	Noise and Vibration	Noise	**B**	D	D	D	D	D	B	D	D	D	B	D	D
	6	Ground Subsidence	Subsidence/collapse	D	D	D	D	D	D	D	D	D	D	D	D	D
	7	Odor		D	D	D	D	D	D	D	D	D	D	D	D	D
	8	Sediment quality	Soil quality (No.4)	**B**	D	D	D	D	B	D	D	D	D	D	D	D
Natural Environment	9	Protected Area	Environmentally Critical Areas (ECAs)	D	D	D	D	D	D	D	D	D	D	D	D	D
	10	Ecosystem	Terrestrial Biology Freshwater or marine ecology	**C**	D	D	D	C	C	D	C	D	D	C	D	D
	11	Hydrology	Hydrology and oceanography	**B**	D	D	D	D	B	D	D	D	D	D	B	D
	12	Topography and geology	Geography, topography and landslides	**B**	D	D	D	D	B	D	D	D	D	D	B	D
Social Enviro	13	Involuntary resettlement	People	**A**	A	D	D	D	D	D	D	D	D	D	D	D
	14	The poor	People	**C**	C	D	D	D	D	D	D	D	D	D	D	D

	No	Impact Items (JICA)	(Philippines)	Overall Rating	Pre/ During Construction Phase									Operation Phase		
		Affected Activities			Land acquisition and Loss of properties	Change of Land use plan, Control of various activities by regulations for the construction	Reclamation of Wetland, etc.	Deforestation	Alteration to ground by cut land, filling, drilling, tunnel etc.	Operation of Construction Equipment and Vehicles	Construction of Roads, tollgates, parking lots, Access roads for bridges and other related facilities	Traffic Restriction in construction area	Influx of construction workers, construction of base camp	Increase of Through Traffic	Appearance/ Occupancy of Roads and related building structures including tunnel and embankment	Increasing influx of settlers
	15	Indigenous and ethnic people	Indigenous people (IPs)	**C**	C	D	D	D	D	D	D	D	D	D	D	D
	16	Local economy such as employment and livelihood	People	**B**	B	D	D	D	D	D	D	D	D	D	D	D
	17	Land use and utilization of local resources	Land use and classification	**B**	B	D	D	B	D	D	D	D	D	D	D	B
	18	Waste Usage	Hydrology / Hydrogeology/Water quality	**B**	B	D	D	D	B	D	D	D	D	D	B	D
	19	Existing social infrastructures and services	People	**C**	C	D	D	D	D	D	D	D	D	D	C	D
	20	Social institutions such as social infrastructure and local decision making institutions		D	D	D	D	D	D	D	D	D	D	D	D	D
	21	Misdistribution of benefit and damage		D	D	D	D	D	D	D	D	D	D	D	D	D
Social Environment	22	Local conflict of interests	People	**B**	D	D	D	D	D	D	D	D	B	D	D	D
	23	Cultural Heritage	People	**C**	C	D	D	D	D	D	D	D	D	D	D	D
	24	Landscape		D	D	D	D	D	D	D	D	D	D	D	D	D
	25	Gender		D	D	D	D	D	D	D	D	D	D	D	D	D
	26	Right of Children		D	D	D	D	D	D	D	D	D	D	D	D	D
	27	Infectious diseases such as HIV/AIDS	People	**B**	D	D	D	D	B	D	D	D	B	D	D	D
	28	Labor environment (including work safety)		D	D	D	D	D	D	D	D	D	D	D	D	D
Others	29	Accidents	Traffic situation	**B**	D	D	D	D	D	B	D	B	D	B	D	D
	30	Cross Boundary impacts and climate change	Meteorology / Climatology	**C**	D	D	D	C	D	D	D	D	D	C	D	D

Note) Rating:
A: Serious impact is expected. B: Some impact is expected. C: Extent of impact is unknown (**serious impacts are not expected, but survey and analysis shall be done**) D: Few impacts are expected. Detailed quantitative survey is not necessary.
Source: JICA Survey Team

TABLE 13.4-2 REASONS FOR DRAFT SCOPING

Category	No	Impacted Item on JICA Guidelines (Philippines Item)	Rating: Pre/ During Construction	Rating: Operation Phase	Reasons of the Rating
Pollution	1	Air pollution (Air quality & noise)	B	B	**Construction phase:** Temporary negative impacts are expected on air quality due to construction machines and equipment. **Operation phase:** Negative impacts on air quality are expected due to emission from vehicles passing on the new road
	2	Water pollution (Water quality)	B	D	**Construction phase:** Turbid water may be generated by earth works and drilling of tunnel section. Additionally Organic polluted water may be discharged from base camp. **Operation phase:** No serious impacts are expected
	3	Waste (Abandonment)	A	D	**Construction phase:** Construction waste such as waste soil and cutting trees are expected to be generated by deforestation, cutting land and drilling tunnel. Additionally domestic waste and night soil may be generated from construction base camp. **Operation phase:** No serious impacts are expected
	4	Soil contamination (soil quality)	B	D	**Construction phase:** Muck soil from tunnel section may contain oil and chemicals. On the other hand, construction works in other section does which causes soil contamination is not expected, and there are not any polluted lands on the route. **Operation phase:** No impacts are expected
	5	Noise (Noise)	B	B	**Construction phase:** Noise and vibration generation is expected due to works of construction machines and equipment. **Operation phase:** Noise and vibration generation is expected by vehicles passing on the new road.
	6	Ground subsidence (Subsidence)	D	D	No impacts are expected since activities which cause ground subsidence (such as use of large amount of groundwater) not expected and there are any soft ground which causes subsidence.
	7	Odor	D	D	No impacts are expected since activities which cause odor are not expected.
	8	Sediment quality (Soil quality)	B	D	**Construction phase:** Muck soil from tunnel section may contain oil and chemicals. On the other hand, construction works in other section does which causes soil contamination is not expected, and there are not any polluted lands on the route. **Operation phase:** Road operation which causes impacts on sediment quality is not expected.
Natural environment	9	Protected area (ECAs)	D	D	**Construction and operation phase:** No protected area such as designated conservation zone is observed in the project affected area.
	10	Ecosystem (Terrestrial Biology Freshwater or marine ecology)	C	C	**Construction and Operation phase:** Although any designated protected areas and considerable species habitats have not been identified in the construction site, the impacts by deforestation, alteration of ground and construction of road will be assessed based on the baseline survey results.
	11	Hydrology (Hydrology and oceanography)	B	B	**Construction and Operation phase:** Construction of bridges and drainage facility on the route may change hydrological situation of the rivers, and may give impact on flooding situation. Furthermore, Cutting and drilling earthworks may give impact to hydrological situation underground (may cut water vein underground).
	12	Topography and geology (Geography, topography and landslides)	B	B	**Construction and operation phase:** Considerable topography and geological sites are not located in the project area, thus no impact is expected. However there are risks of landslide and collapse in the high-embankment section.
Social environment	13	Involuntary resettlement (People)	A	D	**Pre-Construction phase:** More than 100 buildings to be relocated are estimated on the corridor of impact. **Operation phase:** No impact is expected
	14	The poor (People)	C	C	**Pre-Construction phase:** Impacts will be assessed considering the feature of the local society around the project site. **Operation phase:** Few impacts are expected

Category	No	Impacted Item on JICA Guidelines (Philippines Item)	Rating Pre/ During Construction	Rating Operation Phase	Reasons of the Rating
	15	Indigenous and ethnic people (Indigenous people)	C	C	**Pre-Construction phase:** Although a couple of indigenous people groups are identified in the project area, impacts will be assessed considering the feature of the local society around the project site. **Operation phase:** Few impacts are expected
	16	Local economy such as employment and livelihood	B	D	**Pre-construction phase:** Livelihood of residents and farmers may be affected by resettlement and acquisition of agricultural area and plantation field. **Operation phase:** Few impacts are expected.
	17	Land use and utilization of local resources (Land use and classification)	B	B	**Pre-construction phase:** App. 30m width and 40km area on mainly agricultural areas and plantation areas will be affected by the project. **Operation phase:** Roadside area may be developed as commercial or industrial area in non-designated land use area. Such unplanned development and influx of new settlers may give impact on land use and local resources.
	18	Water usage (Hydrology / Hydrogeology/Water quality)	B	B	**Construction phase:** Earth works such as cutting land and drilling of tunnel may give impact on drinking water resources such as springs and wells. **Operation phase:** Existence of tunnel may give impact on water vein and existing spring water and wells
	19	Existing social infrastructures and services (People)	C	C	**Pre-Construction and Construction phase:** Relocation of religious facilities, school, cemetery and other public facilities need to be considered. **Operation phase:** Existence of bypass may disturb commuting / going to school and hospital.
	20	Social institutions such as social infrastructure and local decision making institutions	D	D	Impacts are not expected, since local decision making institute represented by Barangay, District and Davao city will continue after the road construction.
	21	Misdistribution of benefit and damage	D	D	Misdistribution of benefit and damage caused by the road construction is not expected.
	22	Local conflict of interests (People)	B	D	**Construction phase:** Local inhabitants and local authorities may request to ensure job opportunities as construction workers. **Operation phase:** No impact is expected
	23	Cultural heritage (People)	C	D	**Pre-Construction and Construction Phase:** Impact will be assessed based on the confirmation of cultural heritages around the project site.
	24	Landscape	D	D	**Construction phase:** Few impact is expected **Operation phase:** There are no law-based designated landscape areas around project area. Additionally any recreation sites such as hiking trail, natural parks which provides aesthetic landscape to visitors are not observed along the proposed alignment.
	25	Gender	D	D	Negative impacts specified for women are not expected.
	26	Right of children	D	D	Negative impacts specified for children are not expected.
	27	Infectious diseases such as HIV/AIDS (People)	B	D	**Construction phase:** Infectious diseases such as STD are possible to be spread due to inflow of construction workers. Furthermore, alteration to ground by cut land and filling may provoke to provide habitats of mosquito that possibly transmits dengue fever. **Operation phase:** Road operation which causes infectious diseases is not expected.
	28	Labor environment (including work safety)	B	D	**Construction phase:** Construction work environment needs to be considered in accordance with relevant laws and regulations. **Operation phase:** No impact is expected.
Others	29	Accidents (Traffic situation)	B	B	**Construction phase:** Construction vehicles may use existing local road near residential areas, thus number of traffic accident

Category	No.	Impacted Item on JICA Guidelines (Philippines Item)	Rating		Reasons of the Rating
			Pre/ During Construction	Operation Phase	
					may increase. **Operation phase:** Risks of traffic accidents on the new road is expected.
	30	Cross boundary impacts and climate change (Meteorology / Climatology)	C	C	**Construction phase:** Deforestation for land clearance may give impact on cross boundary impacts and climate change. **Operation phase:** Greenhouse gas around the new road may increase by the traffic. However the estimated total traffic number in the project area, Davao City is same as both cases "With/Without Project", only travelling speed will increase with project case. Thus the project does not give negative impact on this item.

Note) Rating:
A: Serious impact is expected. B: Some impact is expected. C: Extent of impact is unknown (**serious impacts are not expected, but survey and analysis shall be done**) D: Few impacts are expected. Detailed quantitative survey is not necessary.
Source: JICA Survey Team

Category	No.	Impacted Item on JICA Guidelines (Philippines Item)	Rating		Baseline Survey	Forecast Analysis
			Pre/ During Construction	Operation Phase		
Pollution	1	Air pollution (Air quality & noise)	B	B	-Site measurement (7 sites) CO, NO2, SO2 and TPM -Secondary data collection, if any	**Construction Phase:** Qualitative analysis **Operation Phase:** - Quantitative analysis(CO, NO2, SO2 and SPM) (Puf model : calm wind model)
	2	Water pollution (Water quality)	B	D	-Site measurement 5 sites: river water DO, TSS, BOD, COD, pH, Total/Fecal Coliform, temperature -Secondary data collection, if any	**Construction and Phase:** Qualitative analysis
	3	Waste (Abandonment)	A	D	Review of specification on design and construction plan	**During Construction Phase:** Quantitative analysis of volume of cutting trees by type and excavated or drilling soil and muck
	4	Soil contamination (soil quality)	B	D	Review of specification on design and construction plan	**During Construction Phase:** Qualitative analysis
	5	Noise and vibration (Noise)	B	B	Noise -Site measurement (7 sites) $L_{Aeq,10min}$ weekday (in accordance with DENR regulation) -Secondary data collection, if any	**During Construction Phase:** Qualitative analysis based on construction machines on standard formation **Operation Phase:** - Quantitative analysis(ASJ CN-Model 2008)
	8	Sediment quality (Soil quality)	B	D	Literature survey (land use history on affected land of the project)	**During Construction Phase:** Qualitative analysis base on the literature survey
Natural environment	10	Ecosystem (Terrestrial Biology Freshwater or marine ecology)	C	C	Literature survey and site survey for fauna and flora. With regard to Philippine eagles, interview survey from specialist is required.	**During construction and operation phase:** Qualitative analysis base on the literature survey, site survey and construction plan & traffic volume in the future The degree of impact for Philippines Eagles will be anticipated qualitatively.
	11	Hydrology (Hydrology and oceanography)	B	B	Literature survey and referring to hydrographic and geological survey result on feasibility study and designing	**During construction and operation phase:** Quantitative analysis on following items base on the hydrographic analysis for bridge and drainage designing. -Impact on hydrological situation on the rivers and streams -Impact on water vein underground

Category	No.	Impacted Item on JICA Guidelines (Philippines Item)	Rating		Baseline Survey	Forecast Analysis
			Pre/ During Construction	Operation Phase		
						-Impact on flooding situation
	12	Topography and geology (Geography, topography and landslides)	B	B	Literature survey and topographic survey for designing	**During construction and operation phase:** Qualitative analysis base on the topographic analysis for designing
Social environment	13	Involuntary resettlement (People)	A	D	Literature survey and a series of RAP surveys (Inventory of loss assets, census, social economic survey and replacement cost study)	**During construction phase:** Quantitative analysis based on RAP surveys
	14	The poor (People)	C	D	Literature survey and a series of RAP surveys	**During construction phase:** Quantitative analysis based on RAP surveys
	15	Indigenous and ethnic people (Indigenous people)	C	D	Literature survey and a series of RAP surveys	**During construction phase:** Quantitative analysis based on RAP surveys
	16	Local economy such as employment and livelihood (People)	B	D	Literature survey and a series of RAP surveys	**During construction phase:** Qualitative analysis based on RAP surveys
	17	Land use and utilization of local resources (Land use and classification)	B	B	Literature survey and a series of RAP surveys (Confirmation of fishing ground in the crossing rivers such as Davao river is required)	**During construction phase:** Quantitative analysis based on RAP surveys (area of land acquisition by land use)
	18	Water usage (Hydrology / Hydrogeology/Water quality)	B	B	Literature survey, geological survey and water usage survey (identification of springs and wells around tunnel and cutting land areas based on the data from DCWD and RAP survey)	**During construction and operation phase:** Qualitative analysis base on the baseline survey for following items - Impact on springs and wells - Impact on watershed area
	19	Existing social infrastructures and services (People)	C	D	Literature survey and a series of RAP surveys	**During construction phase:** Quantitative analysis based on RAP surveys
	22	Local conflict of interests (People)	B	D	Collection of information and opinions in stakeholder meeting(s)	**During construction:** Qualitative analysis based on RAP surveys and opinions through stakeholder meeting(s)
	23	Cultural heritage (People)	C	D	Literature survey, a series of RAP surveys and collection of local information through stakeholder meeting(s)	**During construction:** Quantitative analysis based on RAP surveys and opinions through stakeholder meeting(s)
	27	Infectious diseases such as HIV/AIDS (People)	B	D	Literature survey and collection of local information through stakeholder meeting(s)	**During construction phase:** Qualitative analysis based on baseline survey. Followings impacts are considered - Risks of HIV/AIDS - Risks of dengue fever - Other specific infection disease
Others	29	Accidents (Traffic situation)	B	B	Collection of traffic accident data from police station	**Operation phase:** Quantitative analysis based on baseline survey

Category	No.	Impacted Item on JICA Guidelines (Philippines Item)	Rating		Baseline Survey	Forecast Analysis
			Pre/ During Construction	Operation Phase		
	30	Cross boundary impacts and climate change (Meteorology / Climatology)	C	C	-Estimation of affected forest area and traffic conditions based on the project plan	**Pre-construction phase at 2013:** Estimation of generated greenhouse gases (CO2) from traffic **Construction phase at 2016** Estimation of generated greenhouse gases (CO2) from traffic and construction machine **Operation phase at 2023 and 2033** Estimation of generated greenhouse gases (CO2) from traffic

Rating:
A: Serious impact is expected. B: Some impact is expected. C: Extent of impact is unknown (**serious impacts are not expected, but survey and analysis shall be done**) D: Few impacts are expected. Detailed quantitative survey is not necessary.
Source: JICA Survey Team

13.5 SUMMARY OF BASELINE SURVEY AND FORECAST

The summarized result of baseline survey and forecast of impacts are shown in **TABLE 13.5-1.** The survey points for air, water quality and noise are shown in **FIGURE 13.5-1**. The baseline data and quantitative forecast of air, water quality and noise are shown in **TABLE 13.5-2**. The survey points of fauna and flora are shown in **FIGURE 13.5-3**.

With regard to pollution items such as air, water and noise, all the forecasted values does not exceed standard values, thus it is not likely to give serious impact on these items. However construction waste soil from cutting land and drilling in the tunnel section should be reused or disposed in appropriate designated disposal site.

Although some species on the IUCN List are identified through the baseline survey on fauna and flora, these species are distributed around the project area. The estimated number of resettlers exceeds 200 persons, thus appropriate mitigation measures are indispensable on the resettlement action plan.

TABLE 13.2.5-1 RESULT OF BASELINE AND FORECAST ON MAIN ITEMS

Category	No.	Impacted Item on JICA Guidelines (Philippines Item)	Rating on the Scoping		Summary of Result		
			Pre/ During Construction	Operation Phase	Baseline	Forecast	Evaluation
Pollution	1	Air pollution (Air quality & noise)	B	B	All measured items (CO, NO2, SO2 and TSP) at 7 points indicated less than standard values. Any sensitive receptors such as school, hospital and residential areas are not observed along the alignment. However a residential area named Elenita Heights (Sta. A6) and the University of Philippine Mindanao is located 200-700 m away from the alignment. (see FIGURE 13.5-1 SITE SURVEY LOCATION FOR AIR, NOISE AND WATER)	Forecasted values for NO2, SO2 and SPM at 2 points in residential area do not exceed standard values.	Expected impacts by the project are not significant because all forecasted values meet standard values.
	2	Water pollution (Water	B	D	All measured items (DO, pH, TSS and BOD) except coliform indicated less than standard	During construction, construction activities may cause turbid water and oil & grease contamination. Additionally organic	As shown on the left, some impacts are expected, thus these impacts are minimized by mitigation measures such

Category	No	Impacted Item on JICA Guidelines (Philippines Item)	Rating on the Scoping: Pre/ During Construction	Rating on the Scoping: Operation Phase	Summary of Result: Baseline	Summary of Result: Forecast	Summary of Result: Evaluation
		quality)			values.	polluted water may be discharged from base camp.	as setting up silt fence, sedimentation pond, portable toilet and appropriate management of construction machines.
	3	Waste (Abandonment)	A	D	Not required	Construction waste such as waste soil and cutting trees are expected to be generated by deforestation, cutting land and drilling tunnel. Additionally domestic waste and night soil may be generated from construction base camp.	As shown on the left, some impacts are expected, thus these impacts are minimized by mitigation measures such as setting up temporary sanitation facilities and appropriate management and disposing in designated site.
	4	Soil contamination (soil quality)	B	D	Not required (contaminated soil is not existing from land use history)	During construction, drilling or muck soil from tunnel section may contain oil and chemicals. It may affect to soil quality around project area.	As shown on the left, some impacts are expected, thus these impacts are minimized by mitigation measures such as appropriate management of construction machines and setting up sedimentation pond, if required.
	5	Noise (Noise)	B	B	All measured noise level at 7 points exceeds standard values. Even in the residential area, the measured level is between 50 and 70 dB(A) for 24 hours due to some sound sources such as Islamic call to prayer, barks of dog, music and insect sounds etc. Any sensitive receptors such as school, hospital and residential areas are not observed along the alignment. However a residential area named Elenita Heights (Sta. N6) and the University of Philippine Mindanao is located 200-700 m away from the alignment. (see FIGURE 13.5 1 SITE SURVEY LOCATION FOR AIR, NOISE AND WATER)	During construction, construction noise affect to the nearest residential area. In operation phase, forecasted values at 2 points on the boundary of ROW and at 2 points in residential area satisfied with the standard noise level.	During construction, as shown on the left, some impacts are expected, thus mitigation measures such as setting up soundproof barriers on the boundary and adoption of working time are planned. In operation phase, although impacts rate by the project is not exceeding the standard values. However, installation of noise barriers near considerable facilities such as school and hospital should be considered, if required. Furthermore, land use management along the road is considered in the near future from the view of secure of buffer zone along the bypass.
	8	Sediment quality (Soil quality)	B	D	Not required	During construction, drilling or muck soil from tunnel section may contain oil and chemicals. It may affect to soil quality in the river around project area.	As shown on the left, some impacts are expected, thus these impacts are minimized by mitigation measures such as appropriate management of construction machines and setting up sedimentation pond, if required.
Natural environment	10	Ecosystem (Terrestrial Biology Freshwater or marine ecology)	C	C	No protected area such as national parks and forest reserves in the project area. As the result of baseline site survey; 1) Trees and understory flora Recorded species: 185 IUCN Red list: 21 (LC:16 and Vul: 5) 2) Birds Recorded species: 29 IUCN Red list: 29 (LC:28 and Vul: 1)	Some listed species on the IUCN red list are observed in the project area. However since these species area distributed in other second forest of Davao City and elsewhere in the remnant forest cover of Mindanao, it is not likely the project gives serious impact on fauna and flora. However the faunal habitats observed to have high species diversity that may be affected by the project are the riparian habitats of Matina River, thus it is recommended to minimize of impacts by mitigation measures.	As shown on the left, some impacts are expected, thus these impacts are minimized by mitigation measures such as relocation & replanting trees along the road under instruction of DENR. Furthermore, appropriate land management will be done by Davao City, so as not to cause unplanned development (i.e., land squatting by migrants) in areas with dense vegetation.

Category	No	Impacted Item on JICA Guidelines (Philippines Item)	Rating on the Scoping: Pre/ During Construction	Rating on the Scoping: Operation Phase	Summary of Result: Baseline	Summary of Result: Forecast	Summary of Result: Evaluation
					3) Bats Recorded species: 4 IUCN Red list: 3 (LC:3) 4) Frogs Recorded species: 5 IUCN Red list: 5 (LC:5) Note) Philippine eagle was neither heard nor observed in the project area. *LC: Least Concern, Vul: Vulnerable (see FIGURE 13.5 3 FLORA AND FAUNA SURVEY LOCATIONS)	With regard to the Philippine Eagle, the no nesting area and no feeding area in the project site in accordance with 3 specialists. The identified nesting are located 11.6 km and 39.5 km away from the project area, thus it is not likely to give serious impact with the Eagle.	
	11	Hydrology (Hydrology and oceanography)	B	B	The major groundwater source is located at the skirt of Mt. Apo and Mt. Talomo named Dumoy area. There are app. 30 wells with depth range -90 to -152 m. In tunnel section, the boring logs indicated the presence of ground water in only 3 of 8 boreholes, but these confirmed layers does not include rich aquifers. Flood is recorded at Lasang, Lacanon, Bunawan, Lipadas and Davao river.	With regard to groundwater source, These existing water sources are located approximately 2-3 km or more from the proposed bypass alignment is not expected to be influenced by the project. In the tunnel section, contained water is extremely law, thus therefore, the flow of water or seepage into the tunnel. Hence it is not likely to give serious impacts on the groundwater. With regard to change of flooding situation, if the bypass is constructed without sufficient drainage, current flood situation will be deteriorated.	It is not likely to give serious impact on the groundwater as shown on the left forecast. With regard to flooding situation, installation of sufficient drainage facilities based on meteorological survey and hydrological surveys will secure stable hydrological situation without flooding.
	12	Topography and geology (Geography, topography and landslides)	B	B	According to the reconnaissance, no slope failure is expected near tunnel section.	Slope failure, soil erosion, and rock fall may potentially occur along high cut slope sections by unstable soil layers of sand and gravel due to cut, weathering, erosion, and water infiltration.	As shown on the left, some impacts are expected, thus these impacts and risks are minimized by mitigation measures such as slope protection.
Social environment	13	Involuntary resettlement (People)	A	D	According to RAP survey, 57 affected dwellings and 228 resettlers are identified.	Land acquisition by the project causes large-scale resettlement. Thus full scale-RAP shall be prepared in accordance with JICA Guidelines.	Appropriate compensation and social assistance in accordance with Resettlement Action Plan (RAP) is prepared and minimize the adverse social impacts.
	14	The poor (People)	C	C	As shown in TABLE 13.10-12, a relatively high percentage of the surveyed households (71.6%) are earning above the poverty threshold of Php 17,040 for a family of four (4) in Region XI DAVAO Region; 7% have annual household incomes that are below the poverty threshold; while the remaining 13.9% are living below the food threshold.	Land acquisition by the project gives some adverse impact to poor people under poverty line.	↑ ditto
	15	Indigenous and ethnic people (Indigenous people)	C	C	According to Davao City, no designated indigenous area is observed. Non Overlap Certificate of the designated indigenous area was issued from the National Commission on	Few impacts are expected	Not required

Category	No	Impacted Item on JICA Guidelines (Philippines Item)	Rating on the Scoping: Pre/ During Construction	Rating on the Scoping: Operation Phase	Summary of Result: Baseline	Summary of Result: Forecast	Summary of Result: Evaluation
					Indigenous Peoples (NCIP) on 26th Aug. 2014		
	16	Local economy such as employment and livelihood (People)	B	D	TABLE 13.10-8 presents the primary source of income of the respondents. As shown on the table, the main source of income is farming (26.4%), followed by own business (22.9%), and professional practice (15.9%). There is also a high percentage who have indicated that they are unemployed or no source of income (17.9%).	Land acquisition by the project gives some adverse impact to tenant farmers and employees of the shops. According to RAP survey, app. 50% PAFs are farmers and own business operators.	Appropriate compensation and social assistance in accordance with Resettlement Action Plan (RAP) is prepared and minimize the adverse social impacts.
	17	Land use and utilization of local resources (Land use and classification)	B	B	According to literature survey based on land use map of Davao City, the project alignment is passing through mainly agricultural area such as plantation and residential zone. The proposed alignment is already incorporated in the land use map 2013-2022	Although the proposed will not traverse through Tourist Development Zones (TDZ), it is deemed beneficial for this development zone in terms of providing better access to the site. In terms of the Agricultural Land Zone (AG), impacts are considered as both positive and negative. Positive in the sense that the Bypass can provide better and faster way, and as such more economical way of transporting products from these areas to trading centers and other distribution sites. Negative in the sense that there is an imminent danger of illegal conversion into other uses.	As shown on the left, some impacts are expected, thus these impacts and risks are minimized by appropriate land management along the bypass under Davao City.
	18	Water usage (Hydrology / Hydrogeology/ Water quality)	B	B	Main drinking water source in Davao City is groundwater located in Dumoy area, not river water. Most of the study sites are near human settlements and are generally used for domestic purposes such as bathing and doing laundry.	During construction, construction activities such as earthworks and excavation in the river will cause turbid water and increase suspended solid in the river. This turbid water does not give impact to drinking water, but may affect to domestic use of the river water.	As shown on the left, some impacts are expected, however these impacts are minimized by mitigation measures such as setting up silt fence and sedimentation pond.
	19	Existing social infrastructures and services (People)	C	C	According to RAP survey, any affected social infrastructures such as school, hospital and church are not observed.	The project does not give any impact to social infrastructures. Thus it is not likely to give any serious impacts on this item	Appropriate compensation and social assistance in accordance with Resettlement Action Plan (RAP) is prepared and minimize the adverse social impacts, if any impacts are expected in the detailed design
	22	Local conflict of interests (People)	B	D	A stakeholder requested to provide work opportunities as a construction worker during construction in the stakeholder meetings on scoping stage.	The local conflicts regarding work opportunities between local communities may be raised in case of unfair employment.	This risk is minimized by mitigation measures such as provision of first priority in hiring during construction period.
	23	Cultural heritage (People)	C	D	According to RAP survey, no cultural heritages are observed on the alignment	Few impacts are expected	Not required
	27	Infectious diseases such as HIV/AIDS (People)	B	B	A stakeholder requested not to create a habitat of mosquito that transmits dengue fever in incidental pond in the construction area without appropriate drainage. According to statistical data, dengue cases have remarkably increased from	Infectious diseases such as STD are possible to be spread due to inflow of construction workers. Furthermore, alteration to ground by cut land and filling may provoke to provide habitats of mosquito that possibly transmits dengue fever.	This risk is minimized by mitigation measures such as construction of sufficient drainage, management of construction yard and health check & education for workers.

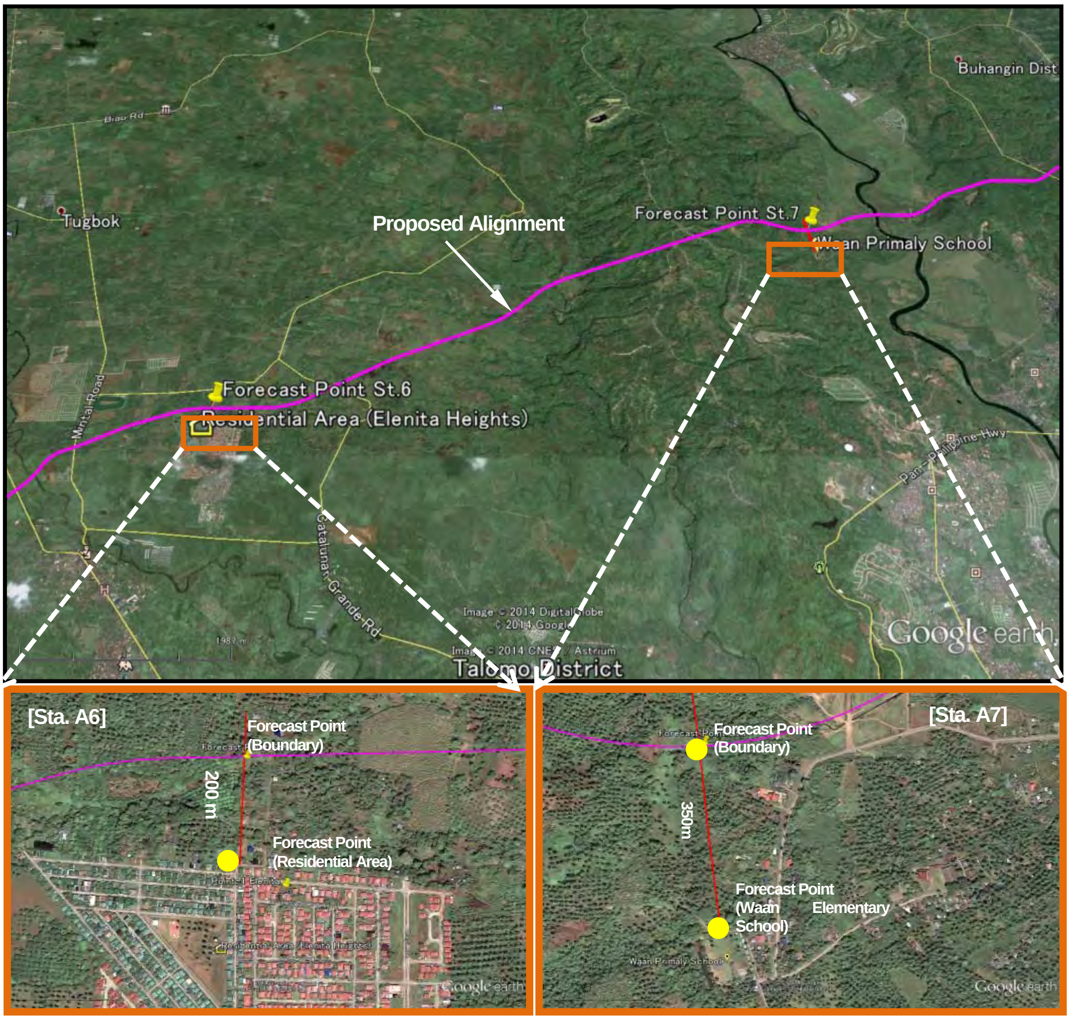
Category	No	Impacted Item on JICA Guidelines (Philippines Item)	Rating on the Scoping: Pre/ During Construction	Rating on the Scoping: Operation Phase	Summary of Result: Baseline	Summary of Result: Forecast	Summary of Result: Evaluation
					3,176 cases in 2008 to 7,326 in 2012, or an increase of about 130.67 percent.		
	28	Labor environment (including work safety)	B	D	Not required	There are risks for workers during construction, if the construction contractor does not comply with relevant labor laws and regulations.	These risks are avoided and minimized by complying with relevant laws and regulations by the contractor under observation of DPWH.
Others	29	Accidents (Traffic situation)	B	B	Not required	Construction vehicles may use existing local road near residential areas, thus number of traffic accident may increase.	These risks are avoided and minimized by installation of traffic sign board, lighting in the night, safety personnel and parking for construction machines.
	30	Cross boundary impacts and climate change (Meteorology / Climatology)	C	C	Not required	Generated estimated CO2 (t/year)volume during construction and operation phase are; Year / Status / Without Project / With Project 2013 / Before Const. / 465,794 / 465,794 2016 / Const. / 475,036 / 547,162 2023 / Operation / 636,936 / 611,336 2033 / Operation / 757,312 / 742,086	Basically the project will give positive impact after construction.

TABLE 13.2.5-2 SUMMARY OF BASELINE AND FORECASTED VALUE (AIR, NOISE and WATER)

No	Item	Baseline Survey (Standard Value)						Quantitative Forecast Analysis (Standard Value)			
1	Air pollution (Air quality & noise)	St.	Location	TSP (300ug/Ncm)	NO2 (260 ug/Ncm)	SO2 (340 ug/Ncm)	CO (30ppm)	SPM (0.1 mg/m3)	NO2 (260 ug/Ncm)	SO2 (340 ug/Ncm)	CO (30ppm)
		A1	Connected road	298.5	6.1	7.8	1.0	-	-	-	-
		A2	Connected road	158.3	3.7	1.8	<1.0	-	-	-	-
		A3	Connected road	128.1	2.4	4.6	<1.0	-	-	-	-
		A4	Connected road& near university	275.9	3.7	13.9	1.0	-	-	-	-
		A5	Connected road	221.1	4.3	5.1	1.0	-	-	-	-
		A6	Residential area (Ambient)	57.7	1.7	0.8	1.0	0.05832	6.7	2.4	-
		A7	Near School (Ambient)	82.0	0.9	1.1	1.0	0.05775	1.7	1.8	-
2	Water pollution (Water quality)	St.	Location	DO (5 mg/l)	TSS (30mg/l)	BOD (7 mg/l)	Total Coli. (1000 MPN/100ml)	Basically waste water is not discharged during and after construction, thus quantitative forecast has not been conducted			
		W1	Lasang River	7.3	ND	1.1	5,400				
		W2	Davao River	7.6	82.0	0.5	9,200				
		W3	Matina River	7.3	2.0	2.0	9,200				
		W4	Talomo River	7.5	4.0	3.9	16,000				
		W5	Lipadas River	7.1	1.0	2.7	9,200				
5	Noise and vibration (Noise)	St.	Location	Laeq dB(A)				Laeq dB(A) (estimated values with BG)			
				Morning N1-5: 60 N6-7:45	Daytime N1-5: 65 N6-7:50	Evening N1-5: 60 N6-7: 45	Night Time N1-5: 55 N6-7: 40	Morning N1-5: 60 N6-7:45	Daytime N1-5: 65 N6-7: 50	Evening N1-5: 60 N6-7: 45	Night Time N1-5: 55 N6-7: 40
		N1	Connected road	-	72	-	-	-	-	-	-
		N2	Connected road	-	72	-	-	-	-	-	-
		N3	Connected road	-	74	-	-	-	-	-	-
		N4	Connected road& near university	-	80	-	-	-	-	-	-
		N5	Connected road	-	73	-	-	-	-	-	-
		N6	Residential area (Ambient)	64	64	57	53	45 (64)	47 (64)	44 (58)	40 (53)
		N7	Near School (Ambient)	62	64	69	62	44 (62)	46 (64)	43 (69)	39 (62)

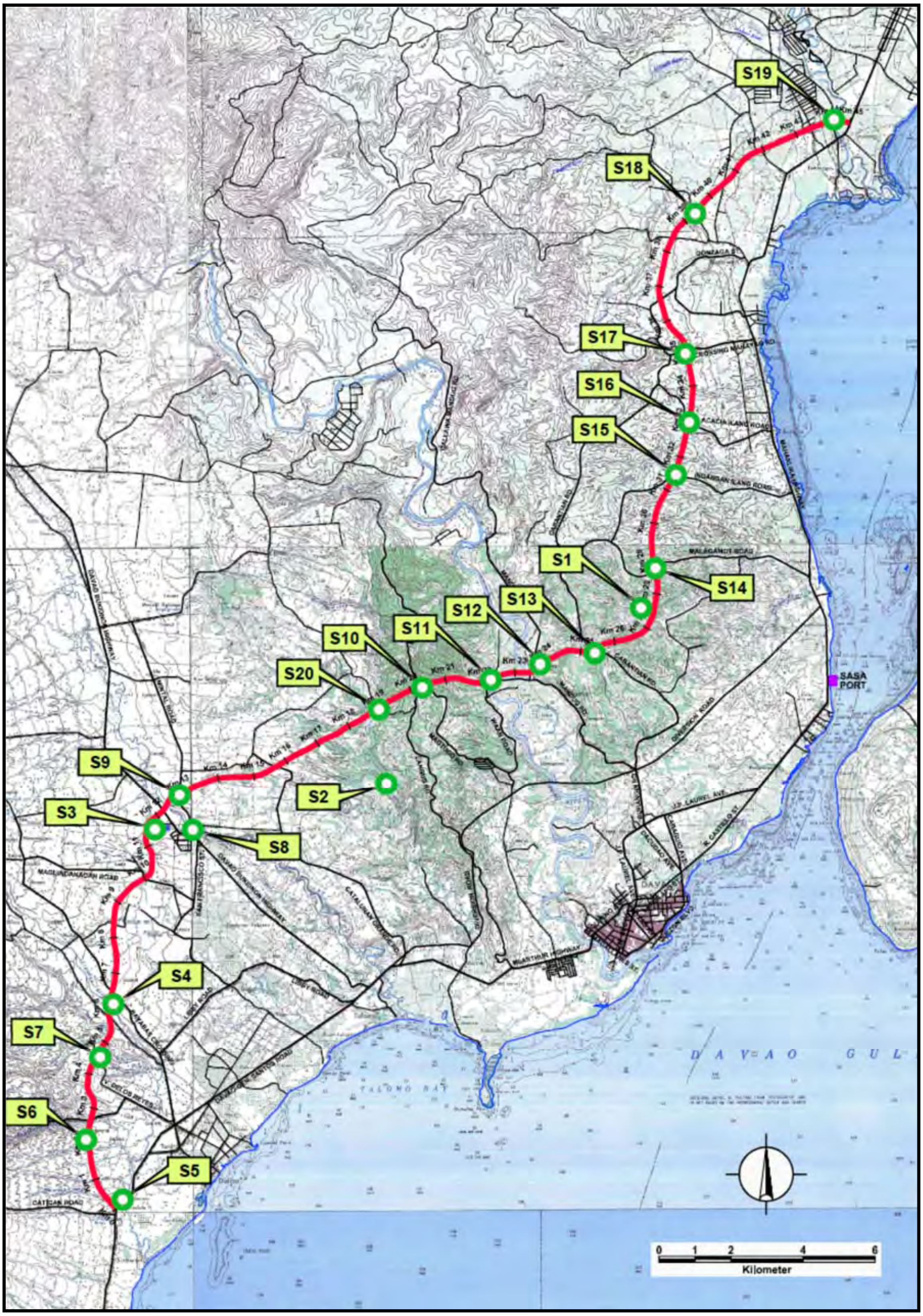
Source: JICA Study Team

FIGURE 13.5-1 SITE SURVEY LOCATION FOR AIR, NOISE AND WATER



Source: JICA Study Team

FIGURE 13.5-2 QUANTITATIVE FORECASTED POINTS FOR AIR AND NOISE



Source: JICA Study Team

FIGURE 13.5-3 FLORA AND FAUNA SURVEY LOCATIONS

13.6 ENVIRONMENTAL MANAGEMENT PLAN

A proposed mitigation plans during and after construction are shown in **TABLE 13.2.6-1**. All mitigation measures are included submitted EIS by DPWH. All cost for mitigation measures are finalized in detailed engineering design phase.

TABLE 13.2.56-1 ENVIRONMENTAL MANAGEMENT PLAN

Category	No	Impacted Item on JICA Guidelines (Philippines Item)	Major Mitigation Measures		Responsibility	
			Pre and During Construction phase	Operation phase	Implementation Agency	Responsible Agency
Pollution	1	Air pollution (Air quality & noise)	[Dust] ✓ Water sprinkling near residential area ✓ 20 kph speed limit for construction machines at construction sites adjacent to settlement areas	[NO2, SO2 and TSP] ✓ Setting up green buffer zone along the road (the zone and planting trees are carried out during construction)	Contractor	[During Const.] DPWH [Operation Phase] Davao and Panabo City
	2	Water pollution (Water quality)	[Turbid water and other items] ✓ Discharge through sedimentation pond and silt fence ✓ Installation of portable toilet for workers ✓ Appropriate waste and construction machines management	Not required	Contractor	DPWH
	3	Waste (Abandonment)	[Construction waste (trees and waste soil)] ✓ After considering the possibility of reuse, construction waste is disposed at **designated disposal site** Note) [Muck soil from tunnel section] ✓ Reuse or disposed at designated disposal site after treatment [Garbage from base camp] ✓ Garbage at workers camp and waste oil shall be brought to disposal site or facility [Night soil] ✓ Temporary sanitation facility such as septic tank shall be introduced to the workers camp.	Not required	Contractor	DPWH
	4	Soil contamination (soil quality)	[Muck soil from tunnel section] ✓ Reuse or disposed at designated disposal site after treatment	Not required	Contractor	DPWH
	5	Noise and vibration (Noise)	[Construction noise] ✓ Installing noise barrier and selecting low-noise equipment. ✓ Avoiding works of heavy equipment during night time. ✓ Informing the construction schedule to surrounding communities to obtain their consensus.	[Traffic noise] ✓Establishment of green belt as buffer zone along the road ✓Secure sufficient distance from boundary of the road to residential area after construction of the road (secure noise decay distance) on land use plan along the road ✓Installation of noise barrier near sensitive facility, if required	Contractor	
	6	Sediment quality (Soil quality)	[Muck soil from tunnel section] ✓ Reuse or disposed at designated disposal site after treatment	Not required	Contractor	DPWH
Natural environment	10	Ecosystem (Terrestrial Biology Freshwater or marine ecology)	✓ Relocation & replanting trees along the road in ROW ✓ Tree planting at sites designated by DENR	✓ Appropriate land use management not to develop natural area along the road	[Const.] Contractor [Operation] Davao and Panabo City	[Const.] DPWH [Operation] Davao and Panabo City
	11	Hydrology (Hydrology and	✓ Designing of bridges with sufficient capacity	Not required	Contractor	DPWH

Category	No	Impacted Item on JICA Guidelines (Philippines Item)	Major Mitigation Measures		Responsibility	
			Pre and During Construction phase	Operation phase	Implementation Agency	Responsible Agency
		oceanography)	✓ Installation of sufficient drainage facilities on bypass ✓ Secure waterways in construction area			
	12	Topography and geology (Geography, topography and landslides)	✓ Installation of slope protection measures	Not required	Contractor	DPWH
Social environment	13	Involuntary resettlement (People)	✓ Appropriate compensation and social assistance in accordance with RAP	✓ Assessing whether resettlement have been met, particularly with regards to livelihood and restoration and/or enhancement of living standards in accordance with RAP	DPWH	Davao and Panabo City
	14	The poor (People)	✓ Appropriate social assistance in accordance with RAP	Not required	DPWH	Davao and Panabo City
	15	Indigenous and ethnic people (Indigenous people)	Not required (NCIP has been issued)	Not required	-	-
	16	Local economy such as employment and livelihood	✓ Appropriate compensation and social assistance in accordance with RAP	Not required	DPWH	Davao and Panabo City
	17	Land use and utilization of local resources (Land use and classification)	✓ Appropriate land acquisition and compensation for agricultural area	✓ Management of appropriate land use in accordance with approved detailed zoning map	[Const.] DPWH [Operation] Davao and Panabo City	Davao and Panabo City
	18	Water usage (Hydrology / Hydrogeology/Water quality)	✓ Installation of alternative water distribution system when unexpected situation such as reduction of spring water and water level of wells	✓ Installation of alternative water distribution system when unexpected situation such as reduction of spring water and water level of wells	DPWH, Davao and Panabo City	DPWH, Davao and Panabo City
	19	Existing social infrastructures and services	✓ Appropriate compensation and/or relocation in accordance with RAP	Not required	Contractor and DPWH	Davao and Panabo City
	22	Local conflict of interests	✓ Local workforce is prioritized for construction of the road.	Not required	Contractor	DPWH
	23	Cultural heritage	✓ Appropriate compensation and/or relocation in accordance with RAP	Not required	DPWH	Davao and Panabo City
	27	Infectious diseases such as dengue and HIV/AIDS	✓ Installation of sufficient drainage facilities not to provide habitat for vector mosquito ✓ Provision of adequate temporary sanitation facilities ✓ Enforcement of medical screening and periodical medical check-up ✓ In order to prevent spread of infectious diseases such as HIV/AIDS, awareness of the labors is promoted	Not required	Contractor	DPWH
	28	Labor environment (including work safety)	✓ Complying with relevant laws and regulations by the contractor under observation of DPWH	Not required	Contractor	DPWH
Others	29	Accidents (Traffic situation)	✓ Deploying flagman at the gate and crossing points of the construction vehicles ✓ Installation of safety sign board	Not required	Contractor	DPWH

Category	No	Impacted Item on JICA Guidelines (Philippines Item)	Major Mitigation Measures		Responsibility	
			Pre and During Construction phase	Operation phase	Implementation Agency	Responsible Agency
			✓ Installing fence around the construction site to keep out local people such as children ✓ Installation of lightning in the night time ✓ Installation of parking for idling construction machines ✓ Restricting mobilization speed in the construction site ✓ Safety training for the workers ✓ Safety patrol at the construction site by supervisors			
	30	Cross boundary impacts and climate change (Meteorology / Climatology)	✓ Replanting natural native trees and other agricultural trees such as coconuts	Not required	Contractor	DPWH

Source: JICA Survey Team

Note) Designated disposal site: One of the candidate disposal sites is existing Magtuod disposal site, however concrete designated disposal sites are concluded in detailed engineering design (DED) stage under discussion with Regional DPWH and Davao and Panabo City.

13.7 ENVIRONMENTAL MONITORING PLAN

13.7.1 INSTITUTIONAL ARRANGEMENT

Environmental management and monitoring organization is shown in **FIGURE 13.7.1-1** which shows concerned agencies by construction stage and their functions.

All planed mitigation measures are carried out by the contractor and reported to the self-monitoring team and multi partite monitoring team (MMT). The monitoring results are reviewed and conducted corrective and preventive action, if necessary. The name of organization which conducts monitoring and environmental management and responsibility is shown in **TABLE 13.7.1-1**.

TABLE 13.7.1-1 ENVIRONMENTAL MANAGEMENT AND MONITORING IMPLEMENTATION ORGANIZATION

Stage	Name of Organization	Role and Responsibility
Pre-Construction and Construction Phases	DPWH-Environment and Social Safeguards Division (ESSD)	• Assist the UPMO Bi-Lateral Cluster 1and the Contractor in the setting up of the Multi-Partite Monitoring Team (MMT); • Overseeing the implementation of the EMP by the Contractor/s; • Overseeing the updating of the Resettlement Action Plan (RAP) after the DED; • Assisting in the conduct of IEC Meetings as enumerated in the IEC Framework of this EIS; • Monitoring actual payments of compensation to affected landowners, structure owners, and crops/trees owners; • In coordination with the Davao City District Engineering Office prepare periodic supervision and monitoring reports on RAP implementation; and • Other necessary roles upon finalization of the RAP during the DED stage
	The Construction Supervision Consultant	• Inspection of mitigation measures and environmental monitoring conducted by the contractor based on the approved EIS • Report the monitoring result to DPWH and donor (JICA) on monthly report

Stage	Name of Organization	Role and Responsibility
	DPWH UPMO Bi-Lateral Cluster 1	• Ensure that compliance to all conditions stipulated in the ECC are included as provisions in the Bid Documents to be issued to prospective Contractors; • Ensure that all engineering interventions in the approved EMP, RAP, and ECC issued are included in the Terms of Reference (TOR) of the Detailed Engineering Design; • Execution of MOA with DENR-EMB Region XI, Davao City and Panabo City LGUs regarding formation and operationalization of the Multi-Partite Monitoring Team (MMT) for implementing the EMoP; and • Other necessary roles upon finalization of the RAP during the DED stage
	Multi-Partite Monitoring Team (MMT) shall be composed of representatives of DPWH, DENR-EMB-FMB, LGUs, NGOs, academia, representative of affected persons and organizations and associations.	• Validate project compliance with the conditions stipulated in the ECC and the EMP; • Validate DPWH's conduct of self-monitoring; • Receive complaints, gather relevant information to facilitate determination of validity of complaints or concerns about the project and timely transmit to the Proponent and EMB recommended measures to address the complaint; • Prepare, integrate and disseminate simplified validation reports to community stakeholders; and • Make regular and timely submission of MMT Reports based on the EMB-prescribed format • Observe/participate as applicable during conduct of monitoring activities; • Coordinate with the Pollution Control Officer (PCO) of Contractors assigned to the Project, to ensure that conditions stipulated in the ECCs are properly complied with, including the gathering of baseline data on air and water quality, and subsequent monitoring of such; • Notify DPWH ESSD about any act or activity by the Contractors that are deemed as violations to the stipulations in the ECCs and amendments issued, and recommend immediate courses of action to avoid or mitigate any violation to said stipulations; and • Compile monitoring data gathered by the Contractors and supervise preparation of semi-annual monitoring reports to be submitted to the DENR
Pre-Construction and Construction Phases	POs and NGOs (Banana Contract Growers, Banana Plantation Owners, Coconut Plantation Owners, and Farmers' Associations)	• Actively participate in ALL activities of the MMT; • Receive complaints from Barangay Homeowners' Associations, women's organizations, and other concerned sectors; • Gather relevant information to facilitate determination of validity of complaints or concerns about the project; • Promptly transmit to the MMT recommended measures to address the complaint; and • Prepare, integrate and disseminate simplified validation reports and feedback to community stakeholders
	The Contractor	• Ensuring that all engineering interventions in the approved EMP, RAP, and ECC issued are included in the Terms of Reference (TOR) of the Detailed Engineering Design; • Implementation of mitigation measures and monitoring based on the approved EMP on EIS and RAP
Operation	DPWH Region XI and Davao City District Engineering Office	• DPWH shall conduct monitoring on the approved EMP on EIA and RAP, and report to DENR and LGUs • The result of monitoring shall be disclosed at DPWH and LGUs • Regular inspection and maintenance of the Bypass Road, including all appurtenant structures • The Planed monitoring is carried out for two (2) years after construction of the bypass

Source: JICA Study Team

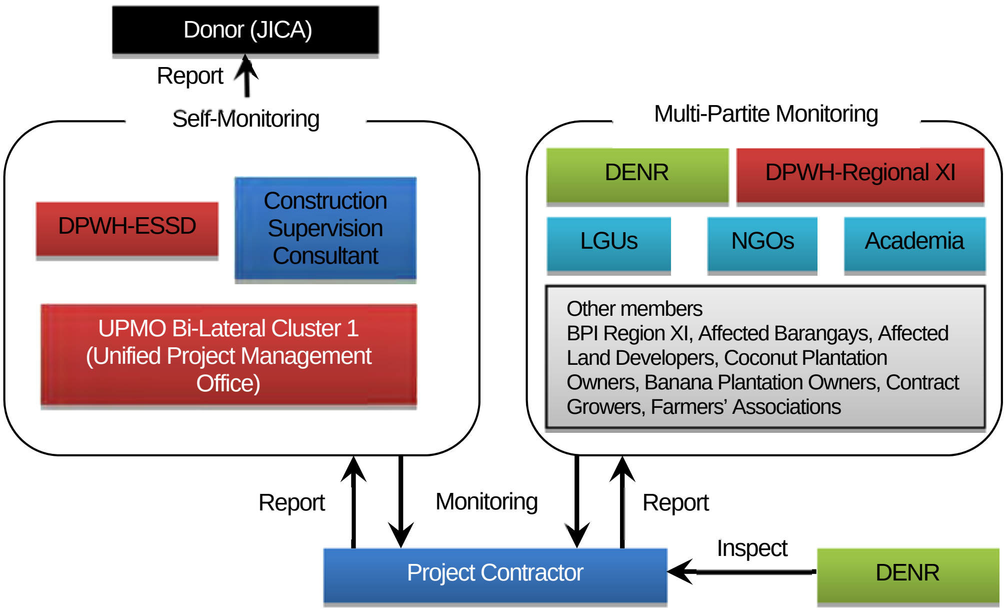


FIGURE 13.7.1-1 ENVIRONMENTAL MANAGEMENT AND MONITORING IMPLEMENTATION ORGANIZATION

13.7.2 ENVIRONMENTAL MONITORING PLAN

A proposed monitoring plan during and after construction are shown in **TABLE 13.7.2-1** and **TABLE 13.7.2-2**.

All monitoring plans are included submitted EIA by DPWH to EMB. The monitoring in operation phase shall be carried out for two (2) years at least.

Proposed items to be monitored by JICA are shown in **TABLE 13.7.2-3**. Air, water quality, noise, ecosystem, resettlement and livelihood of relocated people shall be monitored during and after construction.

TABLE 13.7.2-1 ENVIRONMENTAL MONITORING PLAN (PRE AND DURING CONSTRUCTION)

Category	No.	Impacted Item on JICA Guidelines (Philippines Item)	Parameter	Method	Location	Frequency a year	Cost (peso)	Standard
Pollution	1	Air pollution (Air quality & noise)	TSP, SO2, NO2 and CO	1. TSP –Gravimetric 2. SO2 –Pararosaniline 3. NO2 – Griess Saltzman Reaction 4. CO –Direct Reading (Gas Analyzer)	7 sites (same locations of baseline survey)	2 times	800,000	TSP 300μg/Ncm SO2 340 μg/Ncm NO2 260 μg/Ncm CO 30 ppm
	2	Water pollution (Water quality)	pH, DO, Oil & Grease, BOD, Fecal Coliform/ Total Coliform, and TSS	Methodologies are described in DAO 34-1990 and EMB-DENR Manual for Ambient Water Quality Monitoring Volume I	5 sites (same locations of baseline survey)	2 times	600,000	For Class "C" freshwater pH – 6.5 to 8.5 DO – 5.0 mg/L Oil & Grease – 2.0 mg/L BOD – 7.0 mg/L TSS – not more than 30 mg/L increase
	3	Waste (Abandonment)	Volume of waste soil, cutting tree and domestic garbage	Record volume of generated waste	Cutting land section, tunnel section, cutting tree section and workers camp	4 times	200,000	Generated waste shall be reused or disposed at designated site.

Category	No	Impacted Item on JICA Guidelines (Philippines Item)	Parameter	Method	Location	Frequency a year	Cost (peso)	Standard
	5	Noise and vibration (Noise)	Ambient and road side noise (dB(A)L_{Aeq})	$L_{Aeq,\ 10min}$ during morning, daytime, evening and night time	7 sites (same locations of baseline survey)	2 times	400,000	For "A" categorized areas (general area) Morning: 50 dB(A) Daytime: 60 dB(A) Evening: 50 dB(A) Night : 45 dB(A) For "B" categorized areas (general commercial areas) Morning: 60 dB(A) Daytime: 65 dB(A) Evening: 60 dB(A) Night : 55 dB(A)
Natural environment	10	Ecosystem (Terrestrial Biology Freshwater or marine ecology)	Situation of Cutting tree area	Ocular inspection	Major bridge section	4 times	200,000	Cutting tree area is limited on ROW
	11	Hydrology (Hydrology and oceanography)	Flooding situation	Flood level measurement during high precipitation periods Interview with local residents	Flood-prone areas, particularly near major river systems	4 times	200,000	Project activities and structures does not cause flooding
	12	Topography and geology (Geography, topography and landslides)	Stability of slope	Ocular inspection	High cut and high embankment section	4 times	200,000	Must be continuously undertaken until slopes are fairly stable and vegetation cover achieves high survival rate
Social environment	13	Involuntary resettlement (People)	Payment and implementation of social assistance in accordance with RAP	Consultation Meeting and/or Survey with the project affected persons (PAPs)	Affected barangays	Monthly	500,000	Must be completed prior to construction stage
	14	The poor (People)	↑ditto	↑ditto	↑ditto	↑ditto		↑ditto
	16	Local economy such as employment and livelihood	↑ditto	↑ditto	↑ditto	↑ditto		↑ditto
	19	Existing social infrastructures and services	↑ditto	↑ditto	↑ditto	↑ditto		↑ditto
	22	Local conflict of interests	Construction worker's native barangay	Confirmation of workers list from contractor	All barangays on the affected route	4 times		Employment opportunity shall be provided fairly
	27	Infectious diseases such as HIV/AIDS	Number of infected patient	Confirmation of health check list from contractor	All construction workers	4 times		Infection disease rate shall be less than average rate
	28	Labor environment (including work safety)	Number of workers with required instrument such as helmet	Count numbers of workers with instrument	All construction workers (weekly meeting place)	4 times		All workers shall have designated device such as helmet

Source: JICA Study Team

TABLE 13.7.2-2 ENVIRONMENTAL MONITORING PLAN (OPERATION PHASE)

Category	No	Impacted Item on JICA Guidelines (Philippines Item)	Parameter	Method	Location	Frequency a year	Cost (peso)	Standard
Pollution	1	Air pollution (Air quality & noise)	TSP, SO2, NO2 and CO	1. TSP –Gravimetric 2. SO2 –Pararosaniline 3. NO2 – Griess Saltzman Reaction 4. CO –Direct Reading (Gas Analyzer)	7 sites (same locations of baseline survey)	1 time	400,000	TSP 300μg/Ncm SO2 340 μg/Ncm NO2 260 μg/Ncm CO 30 ppm
	2	Water pollution (Water quality)	pH, DO, Oil & Grease, BOD, Fecal Coliform/ Total Coliform, and TSS	Methodologies are described in DAO 34-1990 and EMB-DENR Manual for Ambient Water Quality Monitoring Volume I	5 sites (same locations of baseline survey)	1 times	600,000	For Class "C" freshwater pH – 6.5 to 8.5 DO – 5.0 mg/L Oil & Grease – 2.0 mg/L BOD – 7.0 mg/L TSS – not more than 30 mg/L increase
	5	Noise and vibration (Noise)	Ambient and road side noise (dB(A)L_{Aeq})	$L_{Aeq,10min}$ during morning, daytime, evening and night time	7 sites (same locations of baseline survey)	1 times	200,000	For "A" categorized areas (general area) Morning: 45 dB(A) Daytime: 50 dB(A) Evening: 45 dB(A) Night : 40 dB(A) For "B" categorized Areas (general commercial areas) Morning: 60 dB(A) Daytime: 65 dB(A) Evening: 60 dB(A) Night : 55 dB(A)
Natural environment	10	Ecosystem (Terrestrial Biology Freshwater or marine ecology)	Situation of Cutting tree area	Ocular inspection	Major bridge section	1 times	100,000	Cutting tree area is limited on ROW
	11	Hydrology (Hydrology and oceanography)	Flooding situation	Flood level measurement during high precipitation periods Interview with local residents	Flood-prone areas, particularly near major river systems	1 times	100,000	Project activities and structures does not cause flooding
	12	Topography and geology (Geography, topography and landslides)	Stability of slope	Ocular inspection	High cut and high embankment section	4 times	200,000	Must be continuously undertaken until slopes are fairly stable and vegetation cover achieves high survival rate
Social environment	13	Involuntary resettlement (People)	Payment and implementation of social assistance in accordance with RAP	Consultation Meeting and/or Survey with the project affected persons (PAPs)	Affected barangays	Monthly	500,000	Must be completed prior to construction stage
	14	The poor (People)	↑ditto	↑ditto	↑ditto	↑ditto		↑ditto
	16	Local economy such as employment and livelihood	↑ditto	↑ditto	↑ditto	↑ditto		↑ditto

Category	No	Impacted Item on JICA Guidelines (Philippines Item)	Parameter	Method	Location	Frequency a year	Cost (peso)	Standard
	19	Existing social infrastructures and services	↑ditto	↑ditto	↑ditto	↑ditto		↑ditto
	22	Local conflict of interests	Construction worker's native barangay	Confirmation of workers list from contractor	All barangays on the affected route	Quarterly		Employment opportunity shall be provided fairly
	27	Infectious diseases such as HIV/AIDS	Number of infected patient	Confirmation of health check list from contractor	All construction workers	Quarterly		Infection disease rate shall be less than average rate

Source: JICA Study Team

TABLE 13.7.2-3 ENVIRONMENTAL MONITORING FORM (JICA FORM)

-If environmental reviews indicate the need of monitoring by JICA, JICA undertakes monitoring for necessary items that are decided by environmental reviews. JICA undertakes monitoring based on regular reports including measured data submitted by the project proponent. When necessary, the project proponent should refer to the following monitoring form for submitting reports.

-When monitoring plans including monitoring items, frequencies and methods are decided, project phase or project life cycle (such as construction phase and operation phase) should be considered.

1. Relevant Permission and Public Consultation

Monitoring Item	Monitoring Results during Report Period
Confirmation of relevant written permissions and minutes of meetings for held consultations and meetings	

2. Mitigation Measures/Monitoring

- Air Quality（Traffic /Ambient Air Quality）

Item	Unit	Measured Value （Mean） Along road/Residential area	Measured Value （Max.）	Country's Standards	Referred International Standards (Japanese standard)	Remarks (Measurement Point, Frequency, Method, etc.)
TSP	μg/Ncm	216.4/69.9	298.5/82.0	300	SPM (0.1mg/m3)	– Same points as baseline survey: 7 points (see table 13.5.1) – 2 times a year during construction – Once a year during operation – Air sampler High volume sampler
NO2	μg/Ncm	6.6/1.0	6.1/1.7	260	0.04-0.06(ppm)	
SO2	mg/Ncm	4.0/1.3	13.9/1.1	340	0.04(ppm)	
CO	ppm	<1.0/1.0	1.0/1.0	30	10(ppm)	
					-	

- Water Quality（Water Quality in the river）

	Unit	Measured Value （Mean）	Measured Value （Max.）	Country's Standards	Referred International Standards (Japanese Standards/ B category river)	Remarks (Measurement Point, Frequency, Method, etc.)
pH	-	7.8	8.0	6.5-8.5	6.5-8.5	– Upstream and downstream portions of affected water bodies (see table 13.5.1) – 2 times a year during construction – Once a year during operation – Grab sampling
DO	mg/l	7.4	7.6	5	5	
TSS	mg/l	22.5	82	30	SS 25	
BOD	mg/l	2.0	3.9	7	3	
Total Coliform	1,000 MPN/ 100ml	9,800	16,000	1,000	5,000	

- Noise / Vibration

Item	Unit	Measured Value (Mean)	Measured Value (Max.)	Country's Standards	Referred International Standards (Japanese Standard)	Remarks (Measurement Point, Frequency, Method, etc.)
Noise level	dB(A)	Along the road 74(daytime) Residential area 64(daytime)	Along the road 80(daytime) Residential area 64(daytime)	For "A" categorized areas (general / residential area) Morning: 45 dB(A) Daytime: 50 dB(A) Evening: 45 dB(A) Night : 40 dB(A) For "B" categorized Areas (general commercial areas) Morning: 60 dB(A) Daytime: 65 dB(A) Evening: 60 dB(A) Night : 55 dB(A)	Residential Area 55 (daytime) Commercial Area 60(daytime) Along the trunk road 70 (daytime)	– Same points as baseline survey, – 2 times a year during construction – Once a year during operation – Digital sound level meter

- Odor

Monitoring Item	Monitoring Results during Report Period
Not required	

3. Natural Environment

- Ecosystem

Monitoring Item	Monitoring Results during Report Period
Situation of cutting tree area (during construction) Situation of replanting area along the road (operation phase)	

4. Social Environment

- Resettlement (basically refer to approved RAP)

Monitoring Item	Monitoring Results during Report Period
Number of PAPs to be resettled/ relocated/ provided livelihood assistance where required.	
Inventory and valuation of PAPs' affected assets	
Pre-and post-resettlement incomes of PAPs	
Notice period given to PAPs before shifting them from their original locations within the RoW	
Number and nature of consultations carried out, as well as targeted stakeholders	
PAPs' perspectives on compensation procedures, entitlement packages	
Number of grievances recorded and redressed	
Number of public facilities and utilities to be relocated	

- Living / Livelihood

Monitoring Item	Monitoring Results during Report Period
Not required (including resettlement)	

13.8 STAKEHOLDER MEETING

Totally 10 stakeholder meetings have been held on Scoping stage as shown in **TABLE 13.8-1**. The first stakeholder meeting was held with Davao City and other relevant major landowners for formulation consensus of the route. The second meetings with Davao and Panabo City are prescript Information Education Communication meetings (IEC meeting) based on the Philippines EIA regulations. The third meetings have been held at 7 venues for project affected person in accordance with the EIA regulation.

TABLE 13.7.2-1 CONTENTS OF STAKEHOLDER MEETINGS ON SCOPING STAGE

Date (venues)	Objectives of the meeting	Major Agenda	Participants	No. of Participants
2013 11th October	Selection of alignment	Discussion of alternative alignments and exchange opinions with DPWH, Davao City and major landowners	DPWH (Central and Regional) Davao City Major landowners (company and government agency)	40
2nd and 5th December Two (2) venues 1) Davao City DPWH 2) Panabo City Hall	Information Education and Communications (IEC) in accordance with Philippines EIA Laws	Explanation of project background, objectives, necessity and positive & negative impacts The meeting was held in Davao and Panabo city respectively	DPWH (Central and Regional) Davao and Panabo City (separated) Barangay captains on the proposed alignment	Davao City: 23 Panabo City: 14
16th to 20th December Seven (7) venues 1) Brgy. Hall of Marapangi, 2)Brgy. Hall of Marapangi, 3)Brgy. Hall of Tigatto, 4) Brgy. Catalunan Grande Gym 5) Brgy. Mintal Community Gym, 6) Brgy. Hall of Mahayag, 7) Conference Room Panabo City Hall	Public Scoping in accordance with Philippines EIA Laws	Explanation of project background, objectives, necessity and positive & negative impacts The meeting was held at 7 venues for 26 Barangays in Davao and Panabo city	DPWH (Regional) Davao and Panabo City Other Government agencies Barangay official PAPs and inhabitants NGOs and other organizations	Davao City (26 Barangay) 173 Panabo City (1 Barangay) 6

Source: JICA Survey Team

216 participants have attended IEC and a series of public scoping meetings.

29 project affected persons, 78 Barangay officials, 89 residents, and 49 government officials attended totaling to 216 participants. Major opinions and answers are shown in **TABLE 13.8-2**. Main topics were disaster prevention, land acquisition and loss of assets.

Other planed public consultation on draft EIS stage in accordance with the EIA regulation and explanation of draft RAP will be held in October and November 2014 as shown in **TABLE 13.7.2-3** and **TABLE 13.7.2-1** (AS OF October, 2014)

TABLE 13.7.2-2 MAJOR OPINIONS IN STAKEHOLDER MEETINGS ON SCOPING STAGE

<table>
<tr><th>Date and Objectives</th><th>Agenda</th><th>Major Opinions</th><th>Answers</th></tr>
<tr><td>2013
11th October
Discussion about proposed alignment with major stakeholders</td><td>1. Project background, necessity of the project and component
2. Concept of proposed alignment
3. Exchange opinions</td><td colspan="2">(1) The Business Case Study (BCS) route has been approved on the Development plan for Davao City. Thus minor modification of the route is acceptable for Davao City. (Davao City Planning Section)
(2) Construction of the Davao Bypass give positive impact on not only traffic stream, but also economic development of Davao city. (Davao City Planning Section)
(3) It is necessary to secure safety and in tunnel section (Davao City Planning Section)
(4) The proposed alignment may traverse a compound of the University of Philippines Mindanao, thus detailed confirmation and discussion with head quarter is necessary (Mindanao Philippine University)
(5) It is understandable to construct a tunnel, however some discussions are necessary from the view of cost, environment and traffic safety in the tunnel (Mindanao Philippine University)
(6) The proposed alignment may affect to transmission lines (Private company: Davao Light and Power Company)</td></tr>
<tr><td>2013
2nd and 5th December
Information Education and Communications (IEC) in accordance with EIA Laws</td><td>1. Project background and component
2.EIA and RAP Process
3. Major impacts
4.Tentative schedule
5. Exchange opinions</td><td>1. Davao City (2nd of December, 2013)
(1) The proposed bypass might aggravate the present flooding problem, so mitigating measures to be adopted to manage the current flooding situation (Barangay officials)
(2) Consider implementation of bio-engineering measures to mitigate effects of the project on soil erosion (DPWH)
(3) Width of the proposed right of way for the first phase of the project (Davao City)
(4) Issue on the ownership/management of the trees to be cut (Davao City)
(5) If rehabilitation of the areas to be excavated during implementation of the project is integrated in the design (Davao City)
(6) Have you identified the properties to be traversed by the alignment to determine if there are water resources that will be affected? (Barangay officials)</td><td>(1) Drainage systems will be designed in consideration of the existing flood situation in the study area to prevent aggravation of present flooding situation
(2) Slope protection methods will be adopted not to cause soil erosion
(3) Initially, the ROW is 30 m, but if the DPWH decided to acquire the entire 60 m, the then the ROW will be 30 m on each direction
(4) Most of the trees identified along the bypass alignment are coconut trees. In such case, The EIA/RAP Team will refer to the latest regulations of PHILCOA (Philippine Coconut Authority) regarding the ownership/management of the cut coconut trees. Natural growing trees will be turned over to DENR-FMB Region XI.
(5) Rehabilitation of the excavated areas is included in the design. Also the EIA study will include recommendation on the complete restoration/ rehabilitation of the excavated areas
(6) These properties will only be identified during the parcellary survey which will be conducted after the Feasibility Study (FS). If during the EIA study, water sources are found along the alignment, appropriate mitigating measures will be recommended to protect the identified water sources that may be affected</td></tr>
</table>

Date and Objectives	Agenda	Major Opinions	Answers
		2. Panabo City (5th of December, 2013) (1) Is there a way of extending the bypass road further north of Panabo City? (Mayor of Panabo City) (2) Ending of bypass road on J.P Laurel may add to the existing traffic congestion in the City. Hopeful that JICA will consider connecting the bypass road on their proposed circumferential road of the city government that will ease the traffic problem.	(1) JICA survey team will further review on it (2) It would be best that a proposal letter be submitted to DPWH main office on the concern
16th – 20th December Public Scoping Meetings based on EIA laws	1.Project description	(1) Plans on existing roads to be intersected by the bypass alignment (PAPs/Inhabitants) (2) Time frame of project completion (PAPs/Inhabitants) (3) If access roads to and from the bypass will be provided in the barangays traversed by the alignment (Barangay officials) (4) Exact area to be traversed by the bypass alignment (Barangay officials)	(1) If the proposed bypass will intersect an existing road, a culvert or flyover bridge will be constructed, depending on the type of road (2) Implementation and completion date of the project cannot be determined yet as the project is still in the FS stage (3) All roads to be intersected by the alignment will be maintained. Provision of access points to and from the bypass in the barangays traversed be the alignment will be determined during the Detailed Design stage (4) The exact areas to be traversed by the alignment cannot be determined yet until the parcellary survey is completed during the conduct of the Detailed Engineering Design (DED) stage. The alignment presented is based on the pre-FS
	2. Item on the EIA 2-1 Land (Topography and geology)	(1) Structural integrity of the road should be considered with respect to potential occurrences of high intensity earthquakes (PAPs/Inhabitants(Indigenous People)) (2) If blasting will be adopted method be undertaken for the tunnel section (NGOs/other organizations) (3) Concern on soil erosion along the section of the alignment near the horse race track (adopt adequate soil erosion measures) (PAPs/Inhabitants) (4) Possible occurrence of slope failure at the tunnel section area due to existence of fault lines (NGOs/other organizations) (5) Consider presence of fault lines in the areas traversed by the bypass alignment (PAPs/inhabitants)	(1) Aside from the study undertaken by the geologist of the JICA Study Team, a geo-hazard specialist who is a member of the EIA Study Team will conduct a thorough geological study along the alignment, particularly at the tunnel section to ensure stability of the structure to be constructed (2) Based on the results of the geological study undertaken at the tunnel section, blasting is not necessary during construction since the rock identified in the area is categorized under the soft type (3) Suitable and adequate slope protection measures at bypass road sections identified to have potential slope failures are considered in the design (4) The structural integrity of the tunnel structure will be the utmost concern of the Design Team. The tunnel structure will be designed with consideration to the existing fault lines and other geological factors to ensure its stability to withstand high intensity earthquake occurrences (5) DPWH in cooperation with JICA Survey Team as well as the EIA Study Team is composed of experts from the different disciplines of the environment that includes a geo-hazard specialist, who is undertaking the study on the existing ground hazards, particularly at the tunnel section. The findings will be included in the EIA report to be submitted to the DENR
	2-2 Hydrological situation	(1) Possible loss/damage of spring water resources in the tunnel section (Barangay officials) (2) Possible stagnation of water along natural waterways crossed by	(1) Part of the Environmental Impact Assessment (EIA) is to identify existence of natural water sources and assess the potential effects of the project (2) Culverts and/or bridges will be constructed along the waterways to be crossed by the

Date and Objectives	Agenda	Major Opinions	Answers
		the alignment due to improper management of construction spoils and debris, which may also cause dengue outbreak (Barangay officials) (3) The proposed bypass road may aggravate the existing problem of flooding in low-lying areas due to inefficient drainage systems (Barangay officials, PAPs/inhabitants)	alignment. Well engineered drainage systems will installed along waterways to ensure flooding will not occur. Mitigation measures to ensure proper management of construction spoils and debris will be included in the EIA Study to be undertaken (3) Well engineered drainage systems will be installed along the bypass alignment to ensure that it will not aggravate the existing flood problem experienced in the adjacent low-lying areas
	2-3Social environment (resettlement and indigenous peoples)	(1) If owners of lands to be affected by the bypass alignment will be compensated? (Barangay officials) (2) Provision of alternative livelihoods and compensation to affected informal settlers (Barangay officials) (3) If coconut trees to be cut will be given to the land owners (Barangay officials) (4) Possible restriction of access to existing roads for farmers going to their farmlands. Probable safety hazard to farmers accessing their lands adjacent to the bypass road (PAPs/inhabitants) (5) If the landowner has rights to any natural resources or treasures that maybe extracted from his property, particularly at the tunnel section (Barangay officials) (6) Entitlements of the landowners on top of the tunnel section. Compensation for affected residential structure owners or communities on the top of the tunnel section tunnel section (Barangay officials, NGOs/other organizations) (7) Consideration for affected IPs who are categorized as informal settlers (PAPs/inhabitants(Indigenous Peoples)) (8) By tradition, Muslims do not allow relocation of mosques (Barangay officials) (9) Security cameras should be installed in the tunnel section of the bypass road (PAPs/Inhabitants(IPs)) (10) Locals should benefit from the project through employment and short-term business opportunities (Barangay officials)	(1) The government will then offer compensation based on the present BIR zonal valuation of the property. (2) In case of JICA loan project, JICA requires strict compliance on livelihood restoration of PAPs. A Resettlement Action Plan (RAP) which will address all issues concerning the PAPs such as just compensation of affected lands and structures, relocation for informal settlers, livelihood restoration. The RAP will be prepared and implemented prior to construction of the project to ensure that all issues concerning the PAPs are properly and completely settled (3) Once the DPWH purchased the property for ROW purposes, everything will be included in the payment. The cut coconut trees will be turned over to DENR-FMB (Forest Management Bureau) (4) Existing roads to be intersected by the bypass alignment will be maintained. Since the road is on embankment, box culverts or bridge crossings will be provided at intersections depending on the type of road to be crossed by the alignment. The type and size of culverts to be constructed at affected Barangay Roads will be designed in consideration with the farm implements utilized by the farmers in the area to ensure safe and unhampered access to farmlands (5) The landowner only has surface rights to his land. According to the national law, mineral resources found within the country's land such as gold are considered as property of the state (6) Entitlements of the landowners on top of the tunnel section will have to be consulted with the DENR-LMS (Department of Environment and Natural Resources-Land Management Services). Resettlement existing communities and/or compensation residential structure owners on top of the tunnel section will not be necessary since the tunnel opening will be at least 200 m below the surface. In addition, construction of the tunnel section will employ modern technologies without blasting activities (7) A Resettlement Action Plan (RAP) will also be prepared to address the concerns of both formal and informal settlers in the affected area, especially IPs (8) Since the alignment is not final yet, re-alignment at sections which will affect school, church, and mosques will still be considered. If re-alignment is not possible, then a series of consultation meetings will have to be undertaken with the concerned groups (9) The suggestion is noted (10) Priority in hiring of qualified workers in the impact areas is stipulated as one of the conditions of the ECC. Qualified workers will only be required to secure endorsement

Date and Objectives	Agenda	Major Opinions	Answers
			from the Barangay Chairman as a proof of residency in the area
		(11) If schools to be affected by the proposed bypass alignment will be relocated (other government agency)	(11) Schools to be affected will be relocated, but as much as possible alignment sections which would affect educational facilities and other institutional structures will be realigned
		(12) Close coordination with Urban Development and Housing Authority Office (UDHAO) and Urban Poor Affairs Office (UPAO) must be undertaken to prevent violent encounters with the informal settlers during relocation (other government agency)	(12) The issue is noted. The UDHAO and UPAO should be involved to ensure peaceful relocation procedure
		(13) Compensation on affected lands with existing ownership dispute (PAPs/inhabitants)	(13) Compensation will be settled once ownership of the land is determined

TABLE 13.7.2-3 SCHDULED STAKEHOLDER MEETING ON EIA AND RAP

Expected Date	Objectives of the meeting	Major Agenda	Participants	Summary of SHM
2014 October-November	Explanation of draft EIA	- Project outline - Forecasted environmental and social impact - Environmental management plan - Opinion exchange	All citizens of Davao and Panabo city	The result will be inserted into EIS report
2014 October-November	Explanation of draft RAP	Explanation of draft RAP	Mainly PAPs and Barangay officials	The result will be inserted into EIS report

Source: JICA Survey Team

13.9 SCHEDULE

The expected schedule for obtaining of environmental certificate commitment (ECCs) is shown in the next table. Major activities to activate a series of process on ECCs approval plan are as follows;

(1) Procedural Screening by EMB: October 2014

DPWH in cooperation with JICA Survey Team has submitted a draft EIS to EMB, and then EMB has carried out procedural screening for the draft EIS.

(2) Substantive Review of EIS by EMB: October – November 2014

EMB will attend the first EIA Review Committee (EIARC), and comments will be issued from the members of EIARC. Additionally a public consultation in Davao and Panabo City will be held by EMB. The project proponent shall prepare additional information (AI) and modify the draft EIS based on comments and opinions from EIARC and participants of public consultations. The EIARC members will inspect the modified EIS in the final EIARC. This substantive review by EMB will be completed and issued the Environmental Certificate Compliance Certificate (ECC) within 40 working days in accordance with implementing rules and regulations of presidential decree No. 1586, establishing the Philippine environmental impact statement system.

(3) Approval ECC (by middle of November 2014)

DPWH shall obtain ECC from EMB before at least 120 days prior to the loan agreement with Japan Government in accordance with JICA Guidelines.

TABLE 13.7.2-1 EIA SCHEDULE (AS OF OCTOBER, 2014)

Year/ Month		2013						2014											
Work Item	Required Document	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
a. Alternative Analysis of routes and authorization by (DPWH and DAVAO City)		■	■	■	■														
b. Preparation of PDS	Draft PDS (parepared in 15th KUROKI-EcosysCorp) Finalization based on final alighment (by Ecosys)				■														
c. IEC with LGUs, Barangay Captains and DPWH and Public Scoping (IEC member and Affected Person and firms)	Draft PDS base-explanation to stakeholders (Stakeholders to be participated shall be consulted with EMB)		IEC: Dec 2 and 5th P.Scoping: 16-20				■												
1. Project Screening based on PDS (by Proponent)	EIA Coverage and Requirements Screening Check list (ECRSC) - A self-screening form used by the Proponent (refer to ECPs and ECAs)						■	■											
2. Scoping Activity with Environmental Management Breau (EMB)	2-1: Letter Request for Scoping 2-2: Required documents (PDS and other documents) 2-3 Site Visiting by RevCom 2-4 Scoping (TOR of EIA)				Presentation for Scoping Feb. 12th				▲										
3. EIA Study & Report Preparation (by Proponent)	3-1: Environmental Impact Statement										■	■	■	■	■				
4.Procedural Screening of EIS (by EMB)	Scoping and Procedural Screeing Checklist (Confirmation by EMB Review Team)															■			
5. Substantive Review of the EIS (by EMB)	EIA Review Committee Report (prepared by EIARC)															■	■		
6. Submittal of Additional Information from EIARC	Additional Information Report (prepared by Proponent)																■		
7. Public Consultation	Proceedings of the public hearing (Anouncement on news paper once a week x 2 times)												Public consultation for Draft EIA				■		
8. Endorsement of Recommendation by EIARC	Endorsement Letter (by EMB Director)															■	■		
9.Sign-off/Issuance or Denial of Environmental Compliance Certificate (ECC)	ECC issues (by DENR Secretary)																	■	
10. Transmittal of ECC to Concerned NGAs(National Government Agencies)/LGUs(Local Government Units)	Submission of ECC to NGAs and LGUs (by EMB)																	■	
A. JICA Env Committee									▲(Jan.31)									■	
		Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

Source: JICA Survey Team

13.10 RESETTLEMENT ACTION PLAN

13.10.1 Summary of Resettlement and Assets

13.10.1.1 Household Interview Survey

Households in the project area are classified into three (3) types as;

Type A: Households who are living in the residential houses which are affected by the project. A total of 57 households were identified and 39 (or 68 %) households had the interview.

Type B: Households who own to be affected by the project. Estimated number of lots is approximately 331, of which 139 (or 42 %) households were interviewed.

Type C: Households who are living in the project area, but houses and lands are not affected by the project. A total of 23 households were interviewed.

13.10.1.2 Summary of Project Affected Persons (PAPs)

(1) Summary of Survey Result

TABLE 13.10-1 indicates the summary of the number of households and people whose structures are affected and to be relocated. And **TABLE 13.10-2** shows the summary of the number of households which will lose their own land.

Note that the socio-economic survey was started on 16 June 2014, being set it as the cut-off date for the project, in accordance with the definition in World Bank OP 4.12.

TABLE 13.10-1 SUMMARY OF THE ESTIMATED NUMBER OF HOUSEHOLDS TO BE AFFECTED BY THE PROJECT

Location	No. of Households (HHs) Affected (a)	No. of Residential HH Affected in (a) (b)	Status of (a)				No. of people Relocated		PAPs with Loss of Income (i)
			Land-Owner (c)	Lessee (d)	Tenant (e)	Busi-ness (f)	Formal (g)	Lessees of Land (h)	
South	157	23	130	16	11	-	92	--	1
Center	121	1	119	2	-	-	-	4	-
North	110	33	62	42	6	-	-	132	4
Total	**388**	**57**	**311**	**60**	**17**	**-**	**92**	**136**	**5**

Source: JICA Stud Team

Note: HHs affected in (a) indicate all HHs whose lands and structures will be affected, while HHs affected in (b) show the number of HHs whose structures will be only affected.

TABLE 13.10-2 SUMMARY OF THE NUMBER OF HOUSEHOLDS WHO WILL LOSE LAND

Location	No. of Lot Affected	No. of HHs who will Lose Land	Ownership of Land			No. of People who Lose Land
			Owner	Tenant	Lessee/Renter	
South	134	89	107	11	16	356
Center	120	35	119	-	1	140
North	77	20	62	6	9	80
Total	**331**	**144**	**288**	**17**	**26**	**576**

Source: JICA Stud Team

(2) Survey Results

The number of residential houses, households and project-affected persons (PAPs) is shown in **TABLE 13.10-3**, according to the results form interview survey.

TABLE 13.10-3 SUMAMRY OF THE NUMBER OF HOUSEHOLDS TO EFFECTED BY THE PROJECT

Unit: No. of Respondents

Location	Sub -district	No. of HHs Affected (a)	No. of Residential HHs Affected in (a) (b)	Status of (a)				No. of people Relocated		PAPs with Loss of Income (i)
				Land Owner (c)	Lessee (d)	Tenant (e)	Busi-ness (f)	Formal (g)	Lessees of Land (h)	
South	Toril	53	7	40	7	6	-	-	-	-
Center	Tugbok	74	17	50	18	6	-	68	-	1
	Talomo	4	-	1	-	3	-	-	4	-
North	Buhangin	30	2	23	2	5	-	-	8	-
	Bunawan	40	12	25	12	3	-	-	48	4
Total		**201**	**38**	**139**	**39**	**23**	**-**	**68**	**60**	**5**

Source: JICA Stud Team

Note: HHs affected in (a) indicate all HHs whose lands and structures will be affected, while HHs affected in (b) show the number of HHs whose structures will be only affected.

Household Size

Majority of PAPs have household size between 0 to 3 (45.8%) and 4 to 6 (37.1%), which is consistent with data obtained from the CLUP, which gave 4.2 as the average household size of families residing in urban barangays, as shown in **TABLE 13.10-4.**

TABLE 13.10-4 SUMMARY OF PAP'S HOUSEHOLD SIZE

Unit: No. of Respondents

Section	South				Center				North		Total	
Sub-District	Toril		Tugbok		Talomo		Buhangin		Bunawan			
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Household Size												
0 to 3	24	26.1	40	43.5	1	1.1	12	13.0	15	16.3	92	45.8
4 to 6	18	24.0	23	30.7	1	1.3	14	18.7	19	25.3	75	37.3
7 to 9	8	33.3	6	25.0	2	8.3	4	16.7	4	16.7	24	11.9
10 and more	3	30.0	5	50.0	0	0.0	0	0.0	2	20.0	10	5.0
Total	**53**		**74**		**4**		**30**		**40**		**201**	**100**

Source: JICA Stud Team

Household Structure

Majority has households consisting of parents and children (nuclear) living together, with 116 respondents, or 57.7%, as shown in **TABLE 13.10-5**. This is followed by those living with parents and/or siblings, or extended families, with 18.4%. There is also a significant number of PAPs living alone (9.4%), and households living in one structure (14.4%).

TABLE 13.10-5 SUMMARY OF PAP'S HOUSEHOLD SURUCTURE

Unit: No. of Respondents

Section	South				Center				North		Total	
Sub-District	Toril		Tugbok		Talomo		Buhangin		Bunawan			
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Household Structure												
Single	6	31.6	10	52.6	0	0.0	3	15.8	0	0.0	19	9.5
Nuclear	31	26.7	43	37.1	2	1.7	18	15.5	22	19.0	116	57.7
Extended	5	13.5	12	32.4	1	2.7	6	16.2	13	35.1	37	18.4
Joint	11	37.9	9	31.0	1	3.5	3	10.3	5	17.2	29	14.4
Total	**53**		**74**		**4**		**30**		**40**		**201**	**100**

Source: JICA Study Team

Ethno-Linguistic Affiliation

The most common dialect spoken by PAPs is Bisaya/Binisaya. It is the mother tongue of 52.7% of the respondents. It is followed by Cebuano with 26.9%, then by Boholano with 5%, and Davaweño with 3.5%. The remaining 11.9% are shared among the Hiligaynon/Ilongo, Tagalog, and Ilocano dialects as shown in **TABLE 13.10-6**.

TABLE 13.10-6 SUMMARY OF PAP'S ETHNO-LINGUISITIC AFFECTION

Unit: No. of Respondents

Section	South				Center				North		Total	
Sub-District	Toril		Tugbok		Talomo		Buhangin		Bunawan			
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Ethno-Linguistic Affiliation												
Bisaya/Binisaya	37	34.9	31	29.8	1	0.9	17	16.0	20	18.9	106	52.7
Cebuano	6	11.1	29	53.7	1	1.8	6	11.1	12	22.2	54	26.9
Boholano	3	30.0	4	40.0	0	0.0	1	10.0	2	20.0	10	5.0
Davaweño	0	0.0	2	28.6	0	0.0	3	42.9	2	28.6	7	3.5
Hiligaynon/Ilongo	1	12.5	3	37.5	0	0.0	2	25.0	2	25.0	8	4.0
Tagalog	6	66.7	1	11.1	0	0.0	1	11.1	1	11.1	9	4.4
Ilocano	0	0.0	2	100	0	0.0	0	0.0	0	0.0	2	1.0
Others	0	0.0	2	40.0	2	40.0	0	0.0	1	20.0	5	2.5
Total	**53**		**74**		**4**		**30**		**40**		**201**	**100**

Source: JICA Study Team

Residency of PAPs

Almost half of the respondents (45.3%) stated that they have been residents of the area from the 1990's and 2000's. There is also a significant number of respondents who have been residing in the area from the 60's to the 70's (26.9%) indicated in **TABLE 13.10-7**.

TABLE 13.10-7 SUMMARY OF PAP'S LENGTH OF STAY

Unit: No. of Respondents

Section	South				Center				North		Total	
Sub-District	Toril		Tugbok		Talomo		Buhangin		Bunawan			
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Length of Stay												
1930's	0	0.0	1	33.3	0	0.0	2	66.7	0	0.0	3	1.5
1940's	4	30.8	5	38.5	0	0.0	2	15.4	2	15.4	13	6.5
1950's	5	25.0	9	45.0	0	0.0	3	15.0	3	15.0	20	9.9
1960's	3	14.3	10	47.6	1	4.8	3	14.3	4	19.1	21	10.5
1970's	11	33.3	11	33.3	1	3.0	5	15.2	5	15.2	33	16.4
1980's	6	30.0	8	40.0	0	0.0	2	10.0	4	20.0	20	9.9
1990's	12	35.3	12	35.3	1	2.9	1	2.9	8	23.5	34	16.9
2000's	12	21.1	18	31.6	1	1.8	12	21.1	14	24.6	57	28.4
Total	**53**		**74**		**4**		**30**		**40**		**201**	**100**

Source: JICA Study Team

Socio-Economic Status

(i) Primary Occupation

TABLE 13.10-8 presents the primary source of income of the respondents. As shown on the table, the main source of income is farming (26.4%), followed by own business (22.9%), and professional practice (15.9%). There is also a high percentage who have indicated that they are unemployed or no source of income (17.9%).

TABLE 13.10-8 SUMMARY OF PAP'S PRIMARY OCCUPATION

Unit: No. of Respondents

Section	South				Center				North		Total	
Sub-District	Toril		Tugbok		Talomo		Buhangin		Bunawan			
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Primary Occupation												
Farming	18	34.0	24	45.3	1	1.9	4	7.6	6	11.3	53	26.4
Skilled & Unskilled	3	17.7	5	29.4	0	0.0	5	29.4	4	23.5	17	8.4
Professional Practice	13	40.6	6	18.7	1	3.1	8	25.0	4	12.5	32	15.9
Own Business	7	15.2	20	43.5	0	0.0	7	15.2	12	26.1	46	22.9
Agricultural Product	2	28.6	2	28.6	1	14.3	1	14.3	1	14.3	7	3.5
Pension	0	0.0	2	33.3	0	0.0	3	50.0	1	16.7	6	3.0
Others	1	25.0	1	25.0	1	25.0	0	0.0	1	25.0	4	2.0
None	9	25.0	14	28.9	0	0.0	2	5.6	11	30.6	36	17.9
Total	**53**		**74**		**4**		**30**		**40**		**201**	**100**

Source: JICA Study Team

(ii) Tenure on Land Occupied

Majority of the PAPs (79.6%) own their land; the rest are tenants (8.0%), and lessees who are occupying land with permit (11.9%). Distribution of type of land tenure is presented in **TABLE 13.10-9**.

TABLE 13.10-9 SUMMARY OF PAP'S TENURE ON LAND

Unit: No. of Respondents

Section	South				Center				North		Total	
Sub-District	Toril		Tugbok		Talomo		Buhangin		Bunawan			
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Tenure on Land												
Owner	44	27.5	60	37.5	4	2.5	28	17.5	24	15.0	160	79.6
Tenant	6	37.5	6	37.5	0	0.0	2	12.5	2	12.5	16	8.0
Lessee	2	8.3	8	33.3	0	0.0	0	0.0	14	58.3	24	11.9
Institutional	1	100	0	0.0	0	0.0	0	0.0	0	0.0	1	0.5
Total	**53**		**74**		**4**		**30**		**40**		**201**	**100**

Source: JICA Study Team

(iii) Access to Basic Social Services

In terms of educational attainment, result shows that majority of respondents for both sexes have no formal schooling with 33.8% for husbands and higher for females with 49.2% shown in **TABLE 13.10-10**.

TABLE 13.10-10SUMMARY OF PAP7S EDUCATION ATTAINMENT

Unit: No. of Respondents

Section	South				Center				North		Total	
Sub-District	Toril		Tugbok		Talomo		Buhangin		Bunawan			
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Educational Attainment – Husband (Wife)												
Primary	8 (4)	29.6 (16.0)	12 (9)	44.4 (36.0)	0 (0)	0.0 (0.0)	4 (3)	14.8 (12.0)	3 (9)	11.1 (36.0)	27 (25)	13.4 (12.4)
Secondary	11 (3)	27.5 (14.3)	11 (4)	27.5 (19.1)	0 (1)	0.0 (4.8)	5 (7)	12.5 (33.3)	13 (6)	32.5 (28.6)	40 (21)	19.9 (10.5)
Tertiary	15 (10)	40.5 (27.8)	17 (17)	46.0 (47.2)	0 (1)	0.0 (2.8)	3 (4)	8.1 (11.1)	2 (4)	5.4 (11.1)	37 (36)	18.4 (17.9)
Post Graduate	1 (0)	14.3 (0.0)	1 (0)	14.3 (0.0)	0 (1)	0.0 (25.0)	3 (1)	42.9 (25.0)	2 (2)	28.6 (50.0)	7 (4)	3.5 (2.0)
Vocational	0 (1)	0.0 (100)	0 (0)	0.0 (0.0)	0 (0)	0.0 (0.0)	0 (0)	0.0 (0.0)	0 (0)	0.0 (0.0)	0 (1)	0.0 (0.5)
None	16 (33)	23.5 (33.3)	26 (38)	38.2 (38.4)	0 (1)	0.0 (1.1)	14 (13)	20.6 (13.1)	12 (14)	17.7 (14.1)	68 (99)	33.8 (49.2)
No Answer	2 (2)	9.1 (13.3)	7 (6)	31.8 (40.0)	4 (0)	18.2 (0.0)	1 (2)	4.5 (13.3)	8 (5)	36.4 (33.3)	22 (15)	11.0 (7.5)
Total	**53 (53)**		**74 (74)**		**4 (4)**		**30 (30)**		**40 (40)**		**201 (201)**	**100 (100)**

Source: JICA Study Team

TABLE 13.10-11 shows that majority of interviewed PAPs source of drinking water are from Level III (46.8%); i.e., house connections through the Davao City Water District (DCWD), and Level II (34.8%) water supply systems.

TABLE 13.10-11 SUMMARYOF PAP'S SOURCE OF WATER FOR DRINKING

Unit: No. of Respondents

Section	South				Center				North		Total	
Sub-District	Toril		Tugbok		Talomo		Buhangin		Bunawan			
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Source of Water for Drinking												
Level 1	5	9.4	1	1.3	0	0.0	2	6.7	8	20.0	16	8.0
Level III	23	43.4	9	1.3	3	75	9	30.0	26	65.0	70	34.8
DCWD	17	32.1	59	12.2	1	25	14	46.7	3	7.5	94	46.7
Spring Box	2	3.8	1	79.7	0	0.0	0	0.0	0	0.0	3	1.5
Illegal Connection	0	0.0	2	1.3	0	0.0	0	0.0	0	0.0	2	1.0
Private Owned	2	3.8	0	2.7	0	0.0	0	0.0	0	0.0	3	1.5
None	3	5.7	1	1.3	0	0.0	1	2.5	1	2.5	5	2.5
Others	1	1.9	1	0.0	0	0.0	0	0.0	2	5.0	8	4.0
Total	**53**		**74**		**4**		**30**		**40**		**201**	**100**

Source: JICA Study Team

(iv) Poverty Threshold

As shown in **TABLE 13.10-12**, a relatively high percentage of the surveyed households (71.6%) are earning above the poverty threshold of Php 17,040 for a family of four (4) in Region XI DAVAO Region; 7% have annual household incomes that are below the poverty threshold; while the remaining 13.9% are living below the food threshold[1].

TABLE 13.10-12 SUMMARY OF POVERTY THRESHOLD AMONG PAPS

Unit: No. of Respondents

Section	South				Center				North		Total	
Sub-District	Toril		Tugbok		Talomo		Buhangin		Bunawan			
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Poverty Threshold among PAPs												
Above Poverty Threshold	37	18.4	53	26.4	3	1.5	24	11.9	27	13.4	144	71.6
Below Poverty Threshold but above Food Threshold	3	1.5	6	3.0	1	0.5	0	0.0	4	2.0	14	7.0
Below Food Threshold	7	3.5	11	5.5	0	0.0	2	1.0	8	4.0	28	13.9
No Response	6	3.0	4	2.0	0	0.0	4	2.0	1	0.5	15	7.5
Total	**53**		**74**		**4**		**30**		**40**		**201**	**100**

Source: JICA Study Team

For their health needs, 50.2% depend on barangay health centers. A few (11.9%) go to hospitals, and the rest access private clinics and hospitals. In terms of sanitation, majority or 68.0% use semi-flush toilet facilities, 25.0% with flush facilities, and a few still using the Antipolo and open pit type. For their mode of transportation, the top three answers are: (i) tricycles and pedicabs (59.7%), and (ii) jeep, bus, and tricycle (15.9%), and (iii) jeepney (12.4%), which accounts for 88.0% of total respondents.

13.10.1.3 Impact on Land

The number of marginally and severely affected landowners per barangay is shown in **TABLE 13.10-13**. As defined in LARRIP Policy 3rd Edition severely affected land are those where area to be acquired is greater than 20% of the total area of land, or when the remaining portion after land take is no longer economically viable. Considering that the Project is still at the Feasibility Study stage and no parcellary surveys have been conducted, severity of impact may change after conduct of such. Note that for flexibility, basis of valuations presented are of two types, namely: (i) BIR Zonal Values and (ii) Schedule of Fair Market Values of Davao City in accordance with City Ordinance 040-07 Series of 2007, also known as an Ordinance Fixing the Schedule of Fair Market Values (SFMV) of Real Properties Within the Territorial Jurisdiction of Davao City for the 2008 General Revision which took effect in 2009[2].

TABLE 13.10-13 SEVERITY OF IMPACT ON AFFECTED LANDS

City/Sub-District/ Barangay	Total No. of Lots	Severe	Marginal	Total Area (in ha)
Davao City				
Toril				
Sirawan	9	4	5	5.77
Marapangi	21	8	13	11.66
Bato	24	14	10	11.78

[1] Food threshold is the minimum income/expenditure required for a family/individual to meet the basic food needs, which satisfies the nutritional requirements for economically necessary and socially desirable physical activities.

[2] Section 201 of the Local Government Code of 1991 and Article 291 of its Implementing Rules and Regulations (IRR) provide that the Department of Finance (DOF) shall promulgate the necessary rules and regulations for the classification, appraisal, and assessment of real property. For this purpose, the DOF has constituted a Committee composed of the officials and staff of the Bureau of Local Government Finance (BLGF) and Provincial, City and Municipal Assessors to formulate a "Manual on Real Property Appraisal and Assessment Operations", which shall serve as a guide for assessors all over the country. In accordance with Section 1, Chapter III of said Manual, the Provincial, City or Municipal Assessor shall undertake a general revision of real property assessments once every three (3) years, which shall commence upon the enactment of the Schedule of Fair Market Values (SFMV) into an ordinance by the sanggunian (local government law making body) concerned.

City/Sub-District/ Barangay	Total No. of Lots	Severe	Marginal	Total Area (in ha)
Alambre	7	4	3	3.23
Bangkas Heights	7	3	4	5.17
Mulig	24	10	14	15.35
Tugbok				
Mintal	22	14	8	10.05
Tugbok	16	10	6	7.37
Tacunan	46	22	24	30.66
Talomo				
Magtuod	11	6	5	7.68
Buhangin				
Waan	2	0	2	5.75
Tigatto	7	0	7	8.35
Cabantian	28	14	14	11.66
Communal	9	4	5	5.79
Indangan	9	0	9	13.04
Bunawan				
Mudiang	20	11	9	15.84
Tibungco	15	6	9	11.70
Mahayag	19	6	13	17.09
San Isidro	23	6	17	22.40
Lasang	11	0	11	15.96
Panabo City				
J. P. Laurel	1	1	0	1.43
Total	**331**	**144**	**187**	**237.76**

Source: JICA Study Team

13.10.1.4 Impact on Livelihood

TABLE 13.10-14 and **TABLE 13.10-15** show the estimated number of trees and crops (banana hills) that will be affected by the Project per Sub-District. Note that valuation used is based on Davao City's Ordinance No. 040-07, Series of 2007 which took effect in 2009, entitled Ordinance Fixing the Schedule of Fair Market Values (SFMV) of Real Properties within the Territorial Jurisdiction of Davao City for the 2008 General Revision.

TABLE 13.10-14 AFFECTED LOTS AND TYPES OF CULTIVATED CROPS

City/Sub-District/ Barangay	Affected Lots	No. of Lots Dominantly Cultivated with			
		Banana	Mango	Coconut	Various Crops
Davao City					
Toril					
Sirawan	9		2	3	
Marapangi	21	6	8		
Bato	24		3	3	
Alambre	7		2	3	
Bangkas Heights	7				
Mulig	24			10	7
Tugbok					

City/Sub-District/ Barangay	Affected Lots	No. of Lots Dominantly Cultivated with			
		Banana	Mango	Coconut	Various Crops
Mintal	22		3		7
Tugbok	16				
Tacunan	46	2	9	4	4
Talomo					
Magtuod	11	2			
Buhangin					
Waan	2	2	1		
Tigatto	7	1			
Cabantian	28	8	2		
Communal	9	2	1		
Indangan	9	1			
Bunawan					
Mudiang	20		1	4	
Tibungco	15	5		8	
Mahayag	19			9	7
San Isidro	23				6
Lasang	11	8			
Panabo City					
J. P. Laurel	1				
Total	**331**	**37**	**32**	**44**	**31**

Source: JICA Study Team

TABLE 13.10-15IMPACT ON TREES AND CROPS

City/Sub-District/ Barangay	Fruit Trees		Industrial Crops		Intercropped Trees	
	Total No.	Value (Php)	Total No.	Value (Php)	Total No.	Value (Php)
Davao City						
Toril	2,870	980,780	464	139,200	1,813	453,250
Tugbok	1,190	850,020	128	38,400	1,737	434,250
Talomo	898	54,770	30	9,000	258	64,500
Buhangin	8,341	610,820	38	11,400	141	35,250
Bunawan	4,486	308,460	474	142,200	3,390	847,500
Total	**17,785**	**2,804,850**	**997**	**340,200**	**7,339**	**1,834,750**
					Total Davao City	**4,979,800**
Panabo City						
J. P. Laurel	1	950	22	6,600	-	-
Grand Total	**17,786**	**2,805,800**	**1,019**	**346,800**	**7,339**	**4,987,350**

Source: JICA Study Team

13.10.1.5 Project Acceptability

When asked to respondents if they were in favor of the Davao Bypass project, a significant majority (83.1%) responded "Yes" (see **TABLE 13.10-16**). Among the reasons cited, the following were mentioned the most number of times:

For "Yes" answer:

(i) It will bring economic development to the City;

(ii) Better accessibility; and

(iii) It will improve living conditions in the barangay.

For "No" answer (16.9%):

(i) It will entail loss of land and livelihood derived from it.

Most opponents consist of small scale land owners and they felt anxiety by losing tiny farmlands. However, the opinions were not strongly negative and they will accept the project if they can afford to spend a proper life without moving far from the original site.

TABLE 13.10-16 PROJECT ACCEPTABILITY

Unit: No. of Respondents

Section	South				Center		North				Total	
Sub-District	Toril		Tugbok		Talomo		Buhangin		Bunawan			
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Project Acceptability												
Yes	41	24.6	65	2.4	25	15.0	32	19.2	32	19.2	167	83.1
No	12	35.3	9	0.0	5	14.7	8	23.5	8	23.5	34	16.9
Total	**53**		**74**		**4**		**30**		**40**		**201**	**100**

Source: JICA Study Team

13.10.2 Resettlement Policy

The development projects undertaken by the Department of Public Works and Highways (DPWH) must serve the public well and in the design and implementation of such projects, all efforts will be executed to help ensure that Project-affected Persons (PAPs) are not worse off. In addition, the Project should provide an opportunity for the local population to derive benefits from the Project.

This portion shall provide a tool, which will also help ensure that all PAPs along the road project, regardless of their number, receive the appropriate assistance in a fast and timely manner. For achieving the goal, the Project will follow the principles in accordance with those in LARRIPP, which has been based on the World Bank Policy OP/BP 4.12.

1. The Government of the Republic of Philippines is bound to follow the Project Resettlement Policy (the Project Policy) for the Davao City Bypass Project specifically which is intended to comply with the JICA Guidelines.
2. Where there are gaps between the Republic of Philippines legal framework for resettlement and JICA's Policy on Involuntary Resettlement, practicable mutually agreeable approaches will be designed consistent with Government practices and JICA's Policy.
3. Land acquisition and involuntary resettlement will be avoided where feasible, or minimized, by identifying possible alternative project designs that have the least adverse impact on the communities in the project area.
4. Where displacement of households is unavoidable, all PAPs (including communities) losing assets, livelihoods or resources will be fully compensated and assisted so that they can improve, or at least restore, their former economic and social conditions.
5. Compensation and rehabilitation support will be provided to any PAPs, that is, any person or household or business which on account of project implementation would have his, her or their standard of living adversely affected;

- Right, title or interest in any house, interest in, or right to use, any land (including premises, agricultural and grazing land, commercial properties, tenancy, or right in annual or perennial crops and trees or any other fixed or moveable assets, acquired or possessed, temporarily or permanently;
- Income earning opportunities, business, occupation, work or place of residence or habitat adversely affected temporarily or permanently; or
- Social and cultural activities and relationships affected or any other losses that may be identified during the process of resettlement planning.

6. All affected people will be eligible for compensation and rehabilitation assistance, irrespective of tenure status, social or economic standing and any such factors that may discriminate against achievement of the objectives outlined above.
7. Lack of legal rights to the assets lost or adversely affected tenure status and social or economic status will not bar the PAPs from entitlements to such compensation and rehabilitation measures or resettlement objectives.
8. All PAPs residing, working, doing business and/or cultivating land within the project impacted areas as of the date of the latest census and inventory of lost assets (IOL), are entitled to compensation for their lost assets (land and/or non-land assets), at replacement cost, if available and restoration of incomes and businesses, and will be provided with rehabilitation measures sufficient to assist them to improve or at least maintain their pre-project living standards, income-earning capacity and production levels.
9. PAPs that lose only part of their physical assets will not be left with a portion that will be inadequate to sustain their current standard of living. The minimum size of remaining land and structures will be agreed during the resettlement planning process.
10. People temporarily affected are to be considered PAPs and resettlement plans address the issue of temporary acquisition.
11. Where a host community is affected by the development of a resettlement site in that community, the host community shall be involved in any resettlement planning and decision-making. All attempts shall be made to minimize the adverse impacts of resettlement upon host communities.
12. The resettlement plans will be designed in accordance with Land Acquisition, Resettlement, Rehabilitation and Indigenous Peoples' Policy (LARRIPP) of DPWH, 2007 and JICA's Policy on Involuntary Resettlement.
13. The Resettlement Plan will be translated into local languages and disclosed for the reference of PAPs as well as other interested groups.
14. Payment for land and/or non-land assets will be based on the principle of replacement cost.
15. Compensation for PAPs dependent on agricultural activities will be land-based wherever possible.
16. Resettlement assistance will be provided not only for immediate loss, but also for a transition period needed to restore livelihood and standards of living of PAPs. Such support could take the form of short-term jobs, subsistence support, salary maintenance, or similar arrangements.
17. The resettlement plan must consider the needs of those most vulnerable to the adverse impacts of resettlement (including the poor, those without legal title to land, ethnic minorities, women, children, elderly and disabled) and ensure they are considered in resettlement planning and mitigation measures identified. Assistance should be provided to help them improve their socio-economic status.
18. PAPs will be involved in the process of developing and implementing resettlement plans.
19. PAPs and their communities will be consulted about the project, the rights and options available to them, and proposed mitigation measures for adverse effects, and to the extent possible be involved in the decisions that are made concerning their resettlement.
20. Adequate budgetary support will be fully committed and made available to cover the costs of land acquisition (including compensation and income restoration measures) within the agreed implementation period.
21. Displacement does not occur before provision of compensation and of other assistance required for relocation.
22. Sufficient civic infrastructure must be provided in resettlement site prior to relocation.
23. Acquisition of assets, payment of compensation, and the resettlement and start of the livelihood rehabilitation activities of PAPs, will be completed prior to any construction activities, except when a court of law orders so in expropriation cases
24. Livelihood restoration measures must also be in place but not necessarily completed prior to construction activities, as these may be ongoing activities.
25. Organization and administrative arrangements for the effective preparation and implementation of the resettlement plan will be identified and in place prior to the

commencement of the process; this will include the provision of adequate human resources for supervision, consultation, and monitoring of land acquisition and rehabilitation activities.

26. Appropriate reporting (including auditing and redress functions), monitoring and evaluation mechanisms, will be identified and set in place as part of the resettlement management system.
27. An external monitoring group will be hired by the project and will evaluate the resettlement process and final outcome. Such groups may include qualified consultants, NGOs, research institutions or universities.
28. Monitoring reports shall be forwarded directly to the JICA.

13.10.3 Legal Framework

Legal framework pertaining to involuntary resettlement consists of the key legal and administrative instruments, currently in force in the Philippines, which govern involuntary resettlement and key aspects of WB/JICA's Policy. Laws that address eminent domain, compensation, responsible parties, and public information, consultation and grievance procedures are included.

13.10.3.1 Philippine Laws, DPWH Guiding Documents and Other Requirements

(1) The Philippine Constitution (1987)

Article III, Section 1: "No person shall be deprived of life, liberty or property without due process of law, nor shall any person be denied equal protection of the law."

Section 9: "Private property shall not be taken for public use without just compensation."

Article XIII, Section 10: "Urban or poor dwellers shall not be evicted nor dwellings demolished, except in accordance with the law and in a just and humane manner. No resettlement of urban or rural dwellers shall be undertaken without adequate consultation and the communities where they are to be relocated."

(2) Republic Act 8974 (R.A. 8974) "An Act to Facilitate the Acquisition of Right-of-Way, Site or Location for National Government Infrastructure Projects (November 2000)"

RA 8974 provides the different basis for land valuation for the modes of acquisition, negotiated sale and expropriation as follows:

- Implementing rules and regulations: The Implementing Agency, DPWH, shall negotiate with the owner for the purchase of the property by offering first the current zonal value issued by the Bureau of Internal Revenue (BIR) for the area where the property is located.
- Valuation of structures and/or improvements on the land: Based on replacement cost defined as the amount necessary to replace the structure or improvement based on current market prices for materials, equipment, labor, contractor's profit and overhead and all other attendant cost associated with the acquisition and installation in place of the affected improvements/installation.
- Methods of negotiation: The following modes in acquiring title to, and ownership of private property, such as: Donation, Quit Claim, Exchange or Barter, Negotiated Sale or Purchase, Expropriation and such other modes of acquisition authorized by law.
- Zonal value as the first offer: In case the mode of acquisition is through a negotiated sale, the first offer shall be the zonal value of the particular land where the property is located. In case the owner rejects the first offer, DPWH shall renegotiate using the values recommended by the Appraisal Committee or Independent Land Appraiser - as procured by MCA-P and the DPWH.
- Standards in determining market value: The market value of the property to be acquired will be determined using the following standards:
  - The classification and use for which the property is suited;
  - The development costs for improving the land;
  - The value declared by the owner;
  - The current selling price of similar lands in the vicinity;
  - The reasonable disturbance compensation for the removal and/or demolition of certain improvements on the land and for the value for improvements thereon;
  - The size, shape and location, tax declaration and zonal valuation of the land;

- The price of the land as manifested in ocular findings, oral evidence as well as documentary evidence presented; and
- Such facts and events as to enable the affected property owners to have sufficient funds to acquire similarly-situated lands of approximate areas as those required from them by the government and thereby rehabilitate themselves as early as possible.

- Quit Claim: This mode is applicable to private property or land acquired under the provisions of Special Laws, like Commonwealth Act 141, known as the Public Land Act. Under the provision of this law, especially Sec. 122 thereof, a strip of twenty (20) meters of the property acquired under such law is reserved by the government for public use with damages paid for improvements only. The twenty (20) meter strip had subsequently been increased to sixty (60) meters under Presidential Decree 635, which took effect on January 1975, amending Sec. 122, C.A. 141.
- In cases where PAPs/Project-affected Families (PAFs) are qualified for compensation but are in arrears on land taxes, to facilitate the processing of payment on assets acquired from the PAPs with tax arrears, the DPWH will pay the arrears and deduct the amount to the total compensation cost.
- In cases of expropriation. For Structures: In the event that the PAF rejects the compensation for structures at replacement cost offered by DPWH, DPWH or the PAF may take the matter to court. As such, DPWH will deposit with the court in escrow the whole amount of the replacement cost (100%) which the Department offered to the owner as compensation for his/her assets to allow DPWH to proceed with the works. The PAF will receive the replacement costs of the asset one (1) month following the receipt of the decision of the court.
- For Land: If the owner contests the Department's second offered value for compensation for land, the PAF or DPWH may take the matter to court. DPWH shall immediately deposit 100% of the BIR zonal value in an escrow account. The court shall determine the just compensation within sixty (60) days, taking into account the standards for the assessment of the values of the land.

(3) DPWH Land Acquisition, Resettlement, Rehabilitation and Indigenous Peoples Policy (LARRIPP) (March 2007)

The LARRIP provides uniform standards in resettlement planning. It also contains safeguard instruments for indigenous peoples (IPs) affected by infrastructures implemented by DPWH and both foreign and locally funded. The LARRIP contains policies related to involuntary resettlement, the legal basis for land acquisition and involuntary resettlement, compensation and entitlement, policy framework for IPs, implementation procedures that ensure grievances are appropriately acted upon, and measures to ensure public participation both during RAP preparation and implementation. The document also provides for internal and external monitoring of RAP implementation.

(4) Indigenous Peoples' Rights Act (IPRA) 1997

"Consent" is required from affected indigenous peoples before any land taking and/or relocation from their ancestral domain by the project. The IPRA, together with the Free and Prior Informed Consent (FPIC) Guidelines of 2006, will serve as the guiding framework on addressing IP issues.
ng IP issues.

13.10.3.2 Other Applicable Laws and Policies: Executive Orders, Administrative Orders, and Department Orders shall govern the Resettlement.

(1) DPWH Department Order (D.O.) No. 34 (series of 2007)) "Simplified Guidelines for the Validation and Evaluation of Infrastructure Right-of-Way Claims"

This provides a step-by-step methodology and guidance to DPWH resettlement staff on how to validate and evaluate infrastructure ROW claims, conduct title searches, and similar activities.

(2) DPWH D.O. No. 327 (series of 2003) "Guidelines for Land Acquisition and Resettlement Action Plan (LAPRAP) for Infrastructure Projects"

- LAPRAP document shall describe the project, expected impacts and mitigating measures, socio-economic profile of PAPs, compensation package, timetable of implementation, institutional arrangements, monitoring and evaluation arrangements, participation, consultation and grievance procedures.

- LAPRAP shall be prepared using inputs from the IROW Action Plan, the census and socioeconomic survey which were conducted, the detailed engineering study, and the parcellary survey results.
- LAPRAP shall be the basis for qualifying and compensating PAPs for lands, structures and/or improvements that are partially or fully affected by the Department's infrastructure projects in accordance with the qualification entitlement, and compensation guidelines.
- Provision of resettlement sites shall be the responsibility of the Local Government Units (LGUs) concerned, with assistance from the concerned government agencies tasked with providing housing. The DPWH shall coordinate with these LGUs and appropriate government agencies for the resettlement and relocation of qualified PAPs. The acquisition, planning, and development of resettlement sites shall be part of the LAPRAPs, with the responsibility resting mainly with the concerned LGUs, Housing and Urban Development Coordinating Council (HUDCC), National Housing Authority (NHA), and other concerned agencies.
- Where relocation is considered necessary, the receiving LGU (under whose political jurisdiction the relocation site will be located) may seek assistance from DPWH for the provision of basic facilities and services.
- An Indigenous People's Action Plan (IPAP) shall be formulated for IPs if they are affected by the Department's infrastructure projects, in coordination with the National Commission of Indigenous People (NCIP) to ensure that the ancestral domain and culture of the IP are secured.

(3) DPWH D.O. No. 5 (series of 2003) "Creation of the Infrastructure Right of Way and Resettlement Project Management Office (IROW-PMO) and the Implementation of the Improved IROW Process"

- The Implementing Office (IO) shall ensure that IROW costs are always included in project budgets.
- The IO shall formulate a ROW Action Plan during the project identification stage. The Action Plan shall contain the estimated budget for all ROW costs including inflation and contingencies, schedule of implementation, and the areas to be acquired.
- The IO shall provide an estimated cost breakdown of each project to the IROW and Resettlement PMO and the Comptrollership and Financial Management Services (CFMS) prior to any disbursement of funds. The first priority of the budget for a project shall be all costs prior to construction.
- If ROW costs differ from the approved ROW budget after detailed design has been finalized, a budget adjustment shall be approved.
- Feasibility Studies shall be conducted for all projects. The level of detail for these studies will vary, depending on the type, size, and complexity of the project.
- The Environmental Compliance Certificate (ECC) shall be secured before detailed design for all projects. However, for projects costing over P3 00 million, the ECC shall be secured before National Economic and Development Authority (NEDA)/Infrastructure (ICC) approval.
- Parcellary Surveys shall be conducted for all projects in accordance with DO 187 series 2002.
- LAPRAP shall be prepared for all projects, whether local or foreign funded, that will require ROW acquisitions, using a standardized compensation package as defined in IROW Procedural Manual..
- The determination of PAPs and improvements shall be based on the cut-off date, which is the start of the census of PAPs and tagging for improvements.
- The IO shall prepare the final as-built ROW Plan upon completion of the project, for submission to the IROW and Resettlement PMO.

(4) DPWH D.O. No. 187 (series of 2002)

This requires all offices to include the cost of ROW acquisition, squatter relocation, and the development of a resettlement site in the total construction cost of any proposed project. The order also details parcellary surveys to be conducted by a geodetic engineer(s) and submitted to the Land Management Bureau of the Department of Environment and Natural Resources (DENR) for approval.

(5) Executive Order No.113 (E.O. 113) 1995

National roads shall have a ROW width of at least 20 meters in rural areas which may be reduced to 15 meters.

In highly urbanized areas shall be at least 60 meters in unpatented public lands; ROW shall be at least 120 meters though natural forested areas for aesthetic or scientific value.

(6) Section 23, Presidential Decree No. 17, revised Philippine Highway Act, October 5, 1972

This states that "It shall be unlawful for any person to usurp any portion of a right-of-way, to convert any part of any public highway…. to his private use or to obstruct the same in any manner…"

(7) E.O. 1035 (1985)

This provides the procedures and guidelines for the expeditious acquisition by the government of private real properties or rights thereon for infrastructure and other government development projects: financial assistance to displaced tenants, cultural minorities and settlers equivalent to the average annual gross harvest for the last three (3) years and not less than 15,000 Philippine pesos (Php) per hectare; disturbance compensation to agricultural lessees equivalent to five (5) times the average gross harvest during the last five (5) years; compensation for improvements on land acquired under Commonwealth Act 141; and the government has the power to expropriate in case no agreement has been reached.

(8) R.A. 7279 (1992)

The "Urban Development and Housing Act" mandates the provision of a resettlement site, and basic services and safeguards for the homeless and underprivileged citizens.

(9) R.A. 7160 (1991)

The "Local Government Code" which allows the local government units to exercise the power of eminent domain for public use.

(10) R.A. 6389 (1971)

This describes disturbance compensation equivalent to five times the average of the gross harvests on landholding during the last five preceding calendar years.

(11) R.A. 7835 (1994)

This describes the National Shelter Program Implementation/ Resettlement Program. The National Housing Authority shall acquire land and develop it to generate serviced home lots for families displaced from sites earmarked for government infrastructure projects, those occupying danger areas such as waterways, railroad tracks and those qualified for relocation and resettlement under RA 7279.

(12) The Philippines Constitution (1987), Section 14 of Article II

This states that "it recognizes the role of women in nation-building, and shall ensure the fundamental equality before the law of women and men."

(13) R.A. 9710 and Implementing Rules and Regulations (series of 2010) known as the "Magna Carta of Women"

This provides for the following, in regards to the rights of women: equal treatment before the law; protection from all forms of violence; participation and representation; equal access and elimination of discrimination against women in education, scholarships and training; equal rights in all matters related to marriage and family relations; comprehensive health services and health information/education; non-discrimination in employment; and other items.

(14) R.A. 7192

"An Act Promoting the Integration of Women as full and Equal Partners of Men in Development and Nation Building and Other Purposes."

(15) E.O. 273

This approved and adopted the Philippine Plan for Gender-Responsive Development (PPGD), 1995-2025; a successor plan of the expired Philippine Development Plan for Women (PDPW) for 1989-1992.

(16) The Harmonized Gender and Development Guidelines (2007)

This aim to provide a common set of analytical concepts and tools for integrating gender concerns into development programs and projects; and help achieve gender equity in, and empower women through projects and programs.

(17) DPWH and World Bank publication, "A Toolkit on Making Road Infrastructures and Related Facilities Gender Responsive"

This presents the principles, approaches and procedures for making road infrastructures and related facilities sensitive to the differing travel needs and patterns of women and men, especially those from low income sectors who rely solely on public and intermediate modes of transport.

13.10.4 Gap Analysis

Although the World Bank and JICA as well as the Philippines have strong protection clauses for PAPs, there are gaps between the policies. **TABLE 13.10-17** includes a comparison and gap analysis of the policies for some key issues between JICA Guidelines and Philippine relevant regulations.

TABLE 13.10-17 COMPARISON OF POLICIES BETWEEN JICA GUIDELINES AND PHILIPPINE LAWS

JICA Guidelines	Laws and Guidelines of the Philippines	Gap relative to JICA GL	Project Policy
Involuntary resettlement and loss of means of livelihood are to be avoided when feasible by exploring all viable alternatives. (JICA GL)	Land Acquisition, Resettlement, Rehabilitation and Indigenous Peoples' Policy, 2007 (LARRIP), (=WB OP4.12)	None	Same as JICA GL
When population displacement is unavoidable, effective measures to minimize impact and to compensate for losses should be taken. (JICA GL)	LARRIPP	None	Same as JICA GL
People who must be resettled involuntarily and people whose means of livelihood will be hindered or lost must be sufficiently compensated and supported, so that they can improve or at least restore their standard of living, income opportunities and production levels to pre-project levels. (JICA GL)	LARRIPP	None	Same as JICA GL
Compensation must be based on the full replacement cost as much as possible. (JICA GL)	LARRIPP	None	Same as JICA GL
Compensation and other kinds of assistance must be provided prior to displacement. (JICA GL)	DO#5 (2003): unless ROW is purchased project notice of award to contractor cannot be issued, i.e. all kind of compensation is paid before project is commenced	None	Same as JICA GL
For projects that entail large-scale involuntary resettlement, resettlement action plans must be prepared and made available to the public. (JICA GL)	LARRIPP	None	Same as JICA GL
In preparing a resettlement action plan, consultations must be held with the affected people and their	LARRIPP	None	Same as JICA GL

JICA Guidelines	Laws and Guidelines of the Philippines	Gap relative to JICA GL	Project Policy
communities based on sufficient information made available to them in advance. (JICA GL)			
When consultations are held, explanations must be given in a form, manner, and language that are understandable to the affected people. (JICA GL)	LARRIPP	None	Same as JICA GL
Appropriate participation of affected people must be promoted in planning, implementation, and monitoring of resettlement action plans. (JICA GL)	LARRIPP	None	Same as JICA GL
Appropriate and accessible grievance mechanisms must be established for the affected people and their communities. (JICA GL)	LARRIPP	None	Same as JICA GL
Affected people are to be identified and recorded as early as possible in order to establish their eligibility through an initial baseline survey (including population census that serves as an eligibility cut-off date, asset inventory, and socioeconomic survey), preferably at the project identification stage, to prevent a subsequent influx of encroachers of others who wish to take advantage of such benefits. (WB OP 4.12 Para. 6)	LARRIP states the cut-off date as the date of commencement of the census. Resettlement project conducted by LGUs nationwide notifies to public the last day of the census work, and use the date as the cut-off date, so that no eligible PAFs are left uncounted.	None	Affected people are to be identified and recorded as early as possible in order to establish their eligibility through an initial baseline survey (including population census that serves as an eligibility cut-off date, asset inventory, and socioeconomic survey), preferably at the project identification stage, to prevent a subsequent influx of encroachers of others who wish to take advantage of such benefits. The cut-off date for this RAP is the date of commencement of the census. For those who are eligible for compensation but absent during the census work shall be encouraged to communicate with the barangay captains and to attend community consultation meetings to be validated by DPWH.
Eligibility of benefits includes, the PAPs who have formal legal rights to land (including customary and traditional land rights recognized under law), the PAPs who don't have formal legal rights to land at the time of census but have a claim to such land or assets and the PAPs who have no recognizable legal right to the land they are occupying. (WB OP 4.12 Para. 15)	Professional Squatters (as defined by Republic Act 7279) applies to persons who have previously been awarded home lots or housing units by the government but who sold, leased or transferred the same to settle illegally in the same place or in another urban area, and non bona	Professional Squatters and Squatting Syndicates are not eligible for compensation. They may salvage the structure materials by themselves.	All affected people (except professional squatters) will be eligible for compensation and rehabilitation assistance, regardless of tenure status, social or economic standing and any such factors that may discriminate against achievement of the objectives of JICA Guidelines. However, those

JICA Guidelines	Laws and Guidelines of the Philippines	Gap relative to JICA GL	Project Policy
	fide occupants and intruders of lands reserved for socialized housing. Squatting Syndicates (as defined by Republic Act 7279) refers to groups of persons who are engaged in the business of squatter housing for profit or gain. Those persons are ineligible for structure compensation, relocation, and rehabilitation/ inconvenience/income-loss assistance in case their structures are to be demolished in resettlement project according to Republic Act 7279. This definition excludes individuals or groups who simply rent land and housing from professional squatters or squatting syndicates.		who have previously been awarded home lots or housing units by the government but who sold, leased or transferred the same to settle illegally in the same place or in another urban area, and non bona fide occupants and intruders of lands reserved for socialized housing will not be eligible for compensation.
Preference should be given to land-based resettlement strategies for displaced persons whose livelihoods are land-based. (WB OP 4.12 Para. 11)	If feasible, land for land will be provided in terms of a new parcel of land of equivalent productivity, at a location acceptable to PAFs. (LARRIP)	None	Same as WB OP 4.12
Provide support for the transition period (between displacement and livelihood restoration). (WB OP 4. 12, para.6)	* Income Loss. For loss of business/income, the PAF will be entitled to an income rehabilitation assistance to be based on the latest copy of the PAFs' Tax record for 3 months, or not to exceed P 15,000 for severely affected structures. *Inconvenience Allowance The amount of P 10,000 shall be given to PAFs with severely affected structures, which require relocation and new construction. *Rehabilitation assistance Skills training and other development activities equivalent to P 15,000 per family will be provided in coordination with other government agencies, if the present means of livelihood is no longer viable and the PAF will have to engage in a	Upper limit of cash disturbance compensation is limited to Php15,000 according to Philippine laws. The amount of planned Financial assistance and eligibility are explained in the community consultation, Only objection given to the Study Team was to change alignment and not to cause loss of farming lands	The Commission of Audit (COA) and DPWH of Philippine government must amend Departmental Order to pay more than Php15,000 of disturbance and other compensation. DPWH will target all PAFs for Livelihood Rehabilitation Assistance. DPWH will conduct quarterly monitoring about the change of living standard of the PAFs before and after the resettlement. When the PAF are found that their living standard worsen, or whose present means of livelihood became not-viable, DPWH, in coordination with other appropriate institutions, will provide assistances, such as skills and livelihood trainings

JICA Guidelines	Laws and Guidelines of the Philippines	Gap relative to JICA GL	Project Policy
	new income activity. *Transportation Allowance or assistance. If relocating, PAFs to be provided free transportation. Also, informal settlers in urban centers who opt to go back to their place of origin in the province or be shifted to government relocation sites will be provided free transportation. (LARRIP (April, 2007, p. 18, 19)		
Particular attention must be paid to the needs of the vulnerable groups among those displaced, especially those below the poverty line, landless, elderly, women and children, ethnic minorities etc. (WB OP 4.12 Para. 8)	LARRIPP	None	Same as WB OP 4.12

Source: JICA Guidelines for Environmental and Social Considerations (2010), World Bank Operational Policy 4.12 (2001), Land Acquisition, Department of Public Works and Highways Resettlement, Rehabilitation and Indigenous Peoples' Policy (2007), Republic of the Philippines

13.11 COMPENSATION AND ENTITLEMENT

13.11.1 Assets Inventory

Items and tables regarding assets inventory were already shown as indicated:

- Number of households affected in
- **TABLE** 13.10-1**.**
- Number of land lot affected in **TABLE 13.10-2.**

13.11.2 Eligibility

Legal owners of residential, commercial and industrial land who have full title, tax declaration or other acceptable proof of ownership shall be eligible for compensation. Owners of structures, on the other hand, whether they are based on legitimate or informal occupation of lands even by a dweller who has no land title, tax declaration or other acceptable proof of ownerships, shall be compensated based on replacement cost, as defined in the IRR of R. A. 8974. LARRIPP also clearly agrees to the part in WB OP 4.12.
For details compensation and entitlement on the project refer to **TABLE 13.11-1**.

TABLE 13.11-1 ENTITLEMENT MATRIX

Type of Loss	Application	Entitled Person	Compensation/Entitlements
LAND (Classified as Agricultural, Residential, Commercial, or Institutional)	**Severe Impact** More than 20% of the total landholding lost or where less than 20% lost but the remaining land holding become	PAF with Transfer Certificate of Title (TCT) or Tax Declaration (TD, which can be legalized to full title).	PAP will be entitled to: • Cash compensation for loss of entire land in accordance with RA. 8974 as amended and its IRR[3], and the DPWH-LARRIPP. 3-Edition 2007. • If feasible, land for land will be provided in

[3] For details, see chapter 13.10.3 (2) Republic Act 8974 (R.A. 8974) "An Act to Facilitate the Acquisition of Right-of-Way, Site or Location for National Government Infrastructure Projects (November 2000)"

Type of Loss	Application	Entitled Person	Compensation/Entitlements
	economically unviable*: **144 Lots** *e.g. In case farmland is divided by the new alignment and hard to continue product activity.		terms of a new parcel of land of equivalent productivity, at a location acceptable to PAFs. • Original titleholders of free or homesteads patens under CA141*. Public Lands Act will be compensated on land improvements only[4]. • Cash compensation for damaged crops at market value at the time of taking. • If applicable, rehabilitation assistance in the form of skills training equivalent to the amount of Php15, 000 per family, if the present means of livelihood is no longer viable and the PAP will have to engage in a new income activity[5]. *Commonwealth Act
		Tenants of agricultural lands: **19 Tenants**	PAP will be entitled to: • Financial assistance equivalent to the average annual gross harvest for the last 3 years and not less that PhP15, 000 per ha.
	Marginal Impact Less than 20% of the total landholdings lost or where less than 20% lost or where remaining viable for use: **187 Lots**	PAP with TCT or TD (which can be legalized to full title).	PAP will be entitled to: • Cash compensation for affected land. Valuation of compensation shall be the same as described above for PAPs holding TCT or TD, which can be legalized to full title.
STRUCTURES (Classified as Residential/ Commercial/ Public Infrastructure)	**Severe Impact** More than 20% of the total landholding loss or where less than 20% loss but the remaining structure no longer function as intended or no longer viable for continued use: **71 Structures (All structures are presumed to be severely affected until centerline is established during DED).**	PAP with TCT or TD (which can be legalized to full title): **23 PAFs**	PAP will be entitled to: • Cash compensation for entire structure at replacement cost. • Inconvenience allowance equivalent to PhP10, 000 per PAF who needs to transfer elsewhere as a result of land acquisition. If the allowance is lower than the cost spent, additional payment will be basically realized.
		PAP without TCT	PAP will be entitled to: • Cash compensation for entire structure at replacement cost.
		PAPs with small scale commercial establishments: **2 PAPs with sari-sari stores** **1 PAP with lumber store** **2 PAPs with poultry**	• Computed income loss during demolition and reconstruction of their shops but no exceeded one (1) month period.
		Project-affected Owners of structure who are leasing on land occupied: **35 PAFs**	PAP will be entitled to: • Cash compensation for entire structure at replacement cost. • If PAF prefers to be relocated, access to socialized housing shall be offered by Davao

[4] This is because under the Public Land Act or Commonwealth Act 141, free patent land or homestead is awarded to beneficiary on the understanding that a 20 meter strip is reserved for government use in the event it needs to utilize said strip for public use.

[5] In this term, "no longer viable" means that if the means of livelihood is land-based, and the area to be acquired is greater than 20% of the total land area (i.e., severely affected), or where less than 20% is acquired but is remaining land will not be suitable for continuing livelihood activity. Viability can only be validated after Parcellary Survey Plan has been completed (i.e., after approval of detailed engineering design).

Type of Loss	Application	Entitled Person	Compensation/Entitlements
			City, preferably within the same Barangay so as to minimize disruption of livelihood activities and severance of social networks. • Appropriate component of the Livelihood Restoration and Improvement Program.
	Marginal Impact Less than 20% of the total landholding lost or where the remaining structure can still function and is viable for continued use **(All structures are presumed to be severely affected until centerline is established during DED).**	PAP with TCT or TD (which can be legalized to full title)	PAP will be entitled to: • Cash compensation for entire structure at replacement cost.
		PAP without TCT	• Cash compensation for affected portion of the structure to be computed based on replacement cost.
OTHER IMPROVEMENTS (Other non-dwelling structures)	**Severely or Marginally Affected**	PAP with or without TCT, TD, etc. **1 Fence** **2 Sari-sari store structures** **2 Poultry structures** **1 Lumber store** **1 Chapel (private owner)** **5 Storage structures (Bodega)**	PAF will be entitled to: • Cash compensation for the affected improvements at replacement cost.
CROPS, TREES		Owners of: **1,118 Mango trees** **1,156 Coconut trees** **16,648 Banana hills** **7,339 intercropped trees**	• Cash compensation for crops, trees, and perennials at fair market value based on City Ordinance No. 040-07[6] which took effect in 2009 for agricultural and industrial crops. • Cash compensation for perennial trees current market value as prescribed by the DENR. • For coconut trees, an additional PhP 100 per tree to be cut shall be made to comply with the requirement of the Philippine Coconut Authority when applying for Permit to Cut, in accordance with Coconut Reservation Act of 1995.
TUNNEL SECTION		Owners of surface land beneath tunnel section	• Disturbance fee as compensation based on fair valuated price for surface land covered.

Source: JICA Study Team

13.11.3 Valuation and Compensation for Losses

Valuation for compensating loss of land shall be in accordance with Section 5 of FLA 8974. For dwellings and other structures, it shall be based on replacement cost as defined in Section 10 of its Implementing Rules and Regulations (IRR), and the LARRIPP of DPWH. Small-scale commercial establishments like sari-sari stores, which will incur temporary decrease in income due to limited access/frontage, shall also be provided income rehabilitation assistance. Inconvenience allowance shall be given to PAPs with severely affected structures, which require relocation and new construction.

[6] Crops are considered in the valuation of real property. As such, it is included in the Schedule of Fair Market Values for Davao City effective 2009.

Although there are approximately 35 families who own residential dwellings but are just leasing land, 29 of these are staying with their relatives' land and only six (6) are staying in a non-related lessor of land. Although the owners of land that they are now occupying may decide to allow them to transfer in areas within the same properties, it is considered more advantageous for these families to be relocated in a land that they can own. That is, as mentioned and illustrated in the previous Section, thee area areas in Davao City that are earmarked as 'socialized housing' sites. However the affected families' decision must also be respected if they would opt to continue leasing the land from their relatives. What is important is that they are provided with options which may improve their standards of living.

Assuming that the 35 families opt to be relocated, they should be provided free transportation including those who opt to go back to their province) upon their transfer to the relocation sites.

(1) Principle of Replacement Cost

All compensation for land and non-land assets owned by households/shop owners who meet the cut-off date will be based on the principle of replacement cost. Replacement cost is the amount calculated before displacement needed to replace an affected asset without both depreciation and deduction for taxes and/or costs of transaction.

- Existing regulations, methods and market price survey results of DPWH, DENR, DA and LGUs will be used where ever available for compensation calculations for structures, crops and trees.
- Independent asset assessor is assigned to valuate lands, structures, trees and other compensations.
- Houses and other relating structures based on actual current market prices of affected materials, labor and mark-up costs. Unit cost for the materials is applied to the standard price in the region concerned. Based on the unit costs, total cost including direct and indirect expenditures is computed.
- Annual crops equivalent to current market value of crops at the time of compensation.
- For trees like coconut, cash compensation at replacement cost that should be in line with LGU's regulations, if available, is equivalent to current market value given the type and age at the time of compensation based on the official guidance.

(2) How to Determine Market Price

The following scheme refers to how to determine market value based negotiated sale between DPWH and the PAP/PAF:

- The classification and use for which the property is suited;
- The development costs for improving the land;
- The value declared by the owners;
- The current selling price of similar lands in the vicinity;
- The reasonable disturbance compensation for the removal and/or demolition of certain improvements on the land and for the value for improvements thereon;
- The size, shape and location, tax declaration and zonal valuation of the land;
- The price of the land as manifested in the ocular findings, oral as well as documentary evidence presented; and
- Such facts and events as to enable the affected property owners to have sufficient funds to acquire similarly-situated lands of approximate areas as those required from them by the Government, and thereby rehabilitate themselves as early as possible.

(3) How to Treat Land of Tunnel Section

Although no direct impact is expected on the surface of the tunnel section, which is around 200 meters above the tunnel location, careful consideration must be given to avoid the same fate experienced by the National Power Corporation (NAPOCOR) in 2007 when they lost their case against the owners of land above their 115-meter deep tunnel through an affirmation of the Court of Appeals' decision (1996 and 2005) by the Supreme Court in 2007.

Although the case of NAPOCOR seems very similar to the tunnel section of the Bypass, it is important to note that there are also glaring differences such as:

NAPOCOR Tunnel Case:

(i) The <u>landowners were never informed</u> that a tunnel will be constructed 115 m below their parcels of land;

(ii) No consultation meeting with the landowners was undertaken by NAPOCOR prior to the construction of the tunnel;
(iii) NAPOCOR maintained that, "the sub-terrain portion where the underground tunnels were constructed does not belong to respondents because, even conceding the fact that respondents owned the property, their right to the subsoil of the same does not extend beyond what is necessary to enable them to obtain all the utility and convenience that such property can normally give";
(iv) NAPOCOR asserted that "respondents were still able to use the subject property even with the existence of the tunnels, citing as an example the fact that one of the respondents had established his residence on a part of the property";
(v) NAPOCOR concluded that "the underground tunnels 115 meters below respondents' property could not have caused damage or prejudice to respondents and their claim to this effect was, therefore, purely conjectural and speculative".

Davao Bypass Case:

(i) Stakeholders concerned were informed that a tunnel will be constructed 200 m below their parcels of land during IEC with LGUs and public consultation meetings;
(ii) Consultation meetings with stakeholders were undertaken, not only once, but for three (3) times as part of the EIS and RAP preparation process;
(iii) DPWH is aware, and as affirmed through the legal framework of this RAP that "the sub-terrain portion where the underground tunnel will be constructed belong to land owners above it by virtue of Article 437 of the Civil Code of the Philippines".

Based on the foregoing, the following recommendations are deemed proper and in the interest of both parties in the Project:

(i) Include lots above the tunnel section in the Parcellary Survey to be conducted during Detailed Engineering Design (DED);
(ii) Considering that said lots were already included in the RAP Budget provided in this Report, provide the same allotment in the ROW cost;
(iii) During ROW acquisition, apply the same modes of acquisition of lands above tunnel in the same manner as those along the main bypass alignment;
(iv) To avoid possible future court cases due to "the tunnels interfering with respondents' enjoyment of their property and depriving them of its full use and enjoyment", as used by NAPOCOR's respondents, expropriate said parcels so that ownership can be transferred to DPWH;
(v) In case an agreement is reached during negotiation that the landowners' preference to stay is granted by DPWH in exchange for compensation, a written agreement must be carefully drafted, or an annotation in the Title be executed to avoid future complaints by heirs of the landowners;

13.11.4 Relocation Site

Based on actual site investigation using approximate ground location of the alignment, no illegal or informal settlers are determined. According to interviews with structure occupants, two types include as leased private and owned lands. For those situated on leased private land, occupants pay rent to their relatives and non-relatives who own the land, respectively.

For structure owners to be relocated who are leasing land, the following actions are appropriate:

(i) Assuming that owners of the land they are leasing would allow them to transfer in areas not affected by ROW acquisition, prompt payment for structures at replacement cost must be made so that they can resettle with minimum disturbance;
(ii) If their relatives would not allow them to transfer in other parts of the affected land, prompt payment for structures at replacement cost must be made so that they can resettle in another site. They should be assisted in order to have easy access to socialized housing sites identified in the 2013-2022 Comprehensive Zoning Ordinance of Davao City (shown in **FIGURE 13.11-1**). Davao City is mandated by law to identify and allot lands for socialized housing so that in the event there is a requirement to resettle affected people (e.g., as cited in Section 28 of R.A. 7279). The housing sites of Davao City were crafted in accordance with this doctrine, and are to be a possible relocation site for this project. For affected families whose average annual income are below the poverty threshold set by the National Statistical Coordination Board (NSCB) for Davao Region,

they should be assisted to have access to a Community Mortgage Program (CMP)[7] of the government so that they can acquire their own land at affordable monthly amortizations; and

(iii) In the case of Item (ii) above, additional disturbance compensation as well as transportation assistance (including financial and physical assistance regarding freight and logistics in case relocation occurs) must be accorded to the affected families, as stipulated in the DPWH LARRIPP Series of 2007.

13.11.5 Impact on Gender and Other Vulnerable Groups

The project has to pay particular attention to ensure that women are the recipients of the compensation pertaining to their activities and to ensure that women who are de-facto household heads are clearly listed as beneficiaries of compensation and rehabilitation proceedings under the loan. Special attentions will also be given to identifying and addressing the needs of disadvantaged groups such as the landless, the poor, female-headed households, the elderly and the disabled, through measures included in the RAP to try and improve (over and above cash compensations and restoration of) their livelihoods.

The DPWH, in its latest LARRIP Policy recognizes that the "identities and cultures of IPs are inextricably linked to their physical environment and the natural resources on which they depend". That is why in the said Policy it provided comprehensive guidelines so as to ensure that projects they implement "do no further harm to IPs and leave them worse off with the projects than without" indicates a summary of the recognized impacts along with the corresponding safeguard instruments for IPs and Indigenous Cultural Communities (ICCs), as prescribed by in LARRIPP Policy.

TABLE 13.11-2 indicates a summary of the recognized impacts along with the corresponding safeguard instruments for IPs and Indigenous Cultural Communities (ICCs), as prescribed by in LARRIPP Policy. Shown in **TABLE 13.11-3** is the approximate number of families that may be vulnerable to impoverishment if not properly compensated and assisted, particularly those families that are headed by Females, Elderly Males, and most especially Elderly Females, which comprise 23.5%, 8.96%, and 14.93%, of the affected population, respectively. As shown on the table, only a little more than 50% are headed by Male.

[7] The Community Mortgage Program (CMP) is a mortgage financing program of the National Home Mortgage Finance Corporation which assists legally organized associations of underprivileged and homeless citizens to purchase and develop a tract of land under the concept of community ownership. The primary objective of the program is to assist informal settlers to own the lots they occupy, or where they choose to relocate to, and eventually improve their neighborhood and homes to the extent of their affordability.

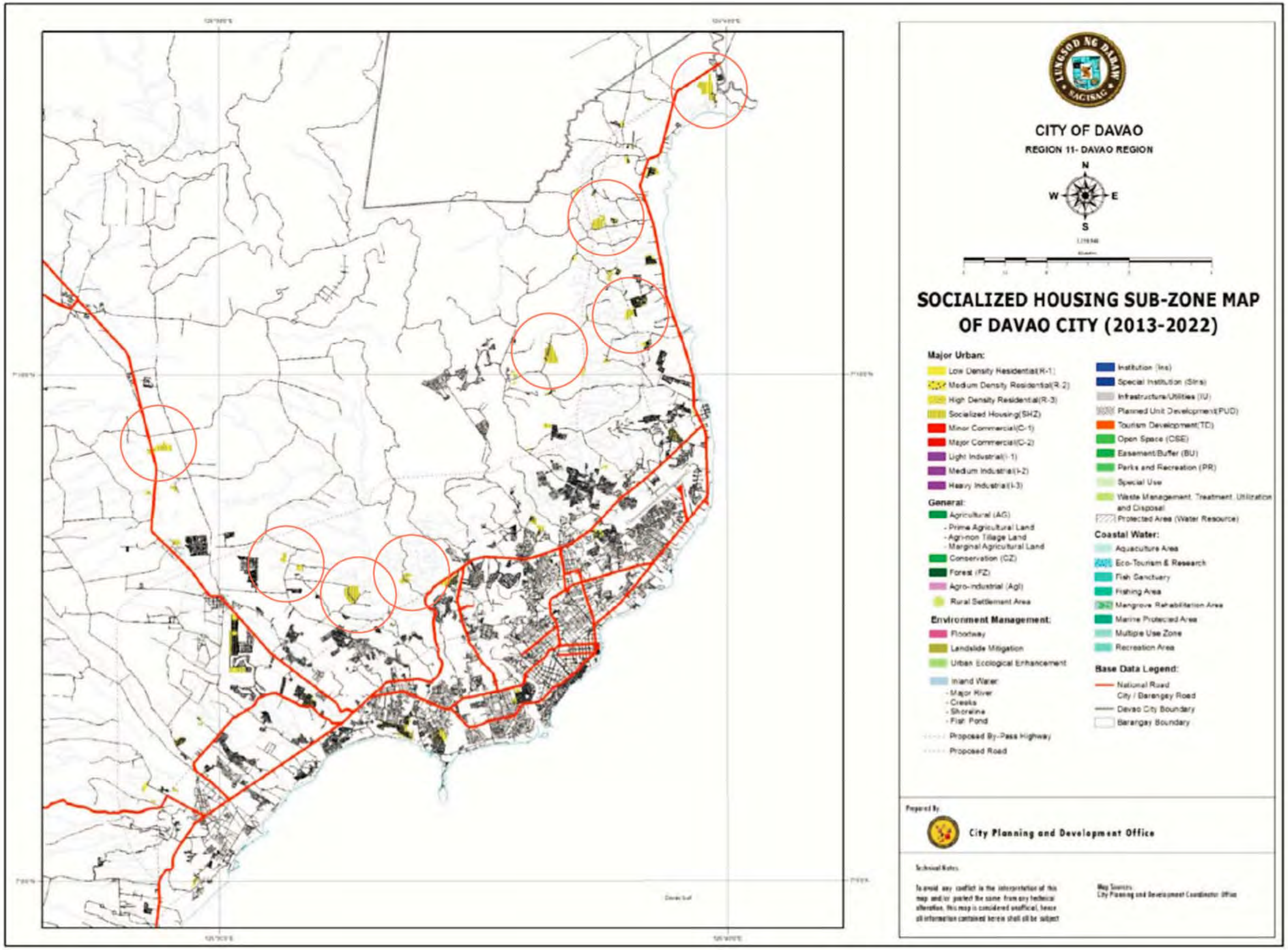


FIGURE 13.11-1 LOCATION OF SOCIALIZED HOUSEING SITES IN DAVAO CITY BASED ON ITS 2013-2022 COMPREHENSIVE ZONE ORDINANCE

TABLE 13.11-2 IMPACTS AND SOCIAL SAFEGUARD INSTRUMENTS FOR IPS AND ICCS BASED ON THE DPWH LARRIPP

Location of Affected IPs	Impact	Relocation Site and Magnitude of Affected Families to be Relocated	Guiding Framework	Safeguard Instrument
Inside Ancestral Domain	Without resettlement	Not Applicable (NA)	FPIC Guidelines of 2006 and/or possible Memorandum of Understanding (MOU) between the DPWH and the NCIP. For compensation and entitlements, Chapter II and III of the LARRIPP and **TABLE 13.11-1** of this report. Other than these entitlements, benefits to be enjoyed by the host ICC/IPs shall be spelled out in the Memorandum of Agreement (MOA) to be executed between the affected ICC/IPs, the project proponent, and other related parties as stipulated in the FPIC Guidelines of 2006.	The MOA serves as the IPAP
	With resettlement	Inside ancestral domain	FPIC Guidelines of 2006 and/or the possible MOU between DPWH and the NCIP. For compensation and entitlements, Chapter II and III of LARRIPP and **TABLE 13.11-1** of this report. Other than these entitlements, benefits to be enjoyed by the host ICCs/IPs shall be spelled out in the MOA.	
		Outside ancestral domain		
		Mixed: Some IPs resettled outside ancestral domain; others remain inside		For those remaining inside the ancestral domain, MOA serves as the IPAP. For those resettled outside the ancestral domain, depending on the magnitude, either a stand-alone IPAP or a special chapter in the resettlement plan.
Outside Ancestral Domain	Without resettlement	NA	For compensation and entitlements, Chapter II and III of LARRIPP and **TABLE 13.11-1** of this report.	Depending on the number of IP PAFs, either a stand-alone IPAP will be drafted or a special IP section in the abbreviated resettlement plan.
	With resettlement	Whole community or a large portion of the community	LARRIPP Governed by possible MOA between the DPWH and NCIP. Options will be explored to resettle IP-PAFs back to their place of origin. If the identified receiving area were an ancestral domain, an FPIC shall be obtained from the receiving IP community. FPIC Guidelines of 2006 and/or possible MOA between DPWH and NCIP shall apply. For compensation and entitlements, Chapter II and III of LARRIPP and **TABLE 13.11-1** of this report.	IPAP
		A few families but	Options to resettle IP-PAFs in the immediate vicinity of the IP	IPAP to cover both PAFs to be resettled

Location of Affected IPs	Impact	Relocation Site and Magnitude of Affected Families to be Relocated	Guiding Framework	Safeguard Instrument
		majority of the IP community remains	community will be explored For compensation and entitlements, Chapter II and III of LARRIPP and **TABLE 13.11-1** of this report.	and the IP community that remains.
Outside of ancestral domain; IPs who have been resettled in public domain lands	With or without resettlement	Whole community or a portion	FPIC Guidelines of 2006. For compensation and entitlements, Chapter II and III of the LARRIPP and **TABLE 13.11-1** of this report.	The MOA serves as the IPAP.

Source: The Environmental and Social Services Office (ESSO) of DPWH, 2007. Land Acquisition, Resettlement, Rehabilitation and Indigenous Peoples Policy, 3rd Edition

TABLE 13.11-3 SUMMARY OF GENDER AND OTHER VULNERABLE GROUPS

Unit: No. of Respondents

Section	South				Center		North				Total	
Sub-District	Toril		Tugbok		Talomo		Buhangin		Bunawan			
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Poverty Threshold among PAPs												
Female	13	24.5	16	21.6	0	0.0	9	30.0	13	32.5	51	23.4
Elderly Female	7	13.2	8	10.8	0	0.0	1	3.3	2	9.0	18	9.0
Male	19	35.8	42	56.8	4	100	16	53.3	21	50.7	102	50.7
Elderly Male	14	26.4	8	10.8	0	0.0	4	13.3	4	14.9	30	14.9
Total	**53**		**74**		**4**		**30**		**40**		**201**	**100**

Source: JICA Study Team

13.12 INSTITUTIONAL ARRANGEMENT

The implementation of the RAP will be pursued by various government offices in cooperation with the PAFs and road concessionaire. In this section, the various players involved in the RAP implementation are named and their respective roles defined. While this project is pursued under the Japan ODA Loan arrangements, the primary responsibility for the implementation of the project still lays with government, specifically the DPWH. This section is based on the Department Administrative Order (DAO) D.O.5, Series of 2003 and the DPWH LARRIPP 3rd Edition.

13.12.1 DPWH UPMO

In accordance with DPWH D.O. 5 and 327 Series of 2003 and the LARRIPP, 3rd Ed. 2007, the Project Implementing Office (IO) shall have the overall responsibility for implementing the project. As such the DPWH Unified Project Management Office (UPMO) shall:

(i) Manage and supervise the Project including land acquisition and resettlement in coordination with other offices within the Department, such as the Infrastructure Right-of-Way office (IROW), the Environment and Social Safeguards Division (ESSD), and the concerned Regional Office (Region XI) as well as other relevant Government agencies (Philippine Coconut Authority (PHILCOA), and LGUs of Davao City and Panabo City);

(ii) Ensure that funds are available so that the RAP can be implemented in a timely manner; and

(iii) Ensure that all funds disbursed in relation to RAP implementation is properly accounted for.

13.12.2 DPWH ESSD

As stipulated in the LARRIPP, the ESSD shall be responsible for providing technical support, guidance, and assistance to the DPWH Implementing Office wit regards to the implementation of the resettlement plan. Acquisition of the needed ROW, including implementation of the RAP such as verification of PAFs, final inventory of affected assets, and actual payment of compensation to the affected families shall be carried out during the conduct of Detailed Engineering Design by the IROW office, or the respective DPWH District Engineering Offices (DEOs) in Davao City and Panabo City, depending on what will be decided upon after the DED is completed.

Some of the tasks, particularly those that are not under the mandate of DPWH remain in gray areas. Some of these include: (i) acquisition of land for relocation sites[8]; (ii) cutting and transport of coconut trees[9], and (iii) community organizing among affected, and host communities in preparation for integration[10] (i.e., if renters

[8] In accordance with R.A. 7279, it is the LGU or the National Housing Authority (NHA) who are mandated to provide land for relocation site. Considering that all affected structure owners are leasing land, it is highly possible that they can afford paying amortization under the Community Mortgage Program (CMP).

[9] This is expected to be done by the Contractor considering that Permit to Cut is applied during construction phase.

[10] The concerned LGU (Davao City) is responsible in coordination with the Presidential Commission for the Urban Poor

of land opt to be relocated).

13.12.3 DPWH Region XI

The DPWH Region XI will oversee the concerned DEO's implementation of the RAP and has the following functions: (i) oversee the activities of DEOs; (ii) monitor the RAP implementation and fund disbursement; (iii) submit monthly progress reports to ESSD; (iv) monitor payments to PAFs; and (v) address grievances filed at its office by the PAFs for speedy resolution.

13.12.4 DPWH District Engineering Office (DEO)

The concerned DEOs will serve as the major player in the implementation of the RAP with the following functions:

(i) Oversee the staking-out, verification and validation of the PAF's affected assets;

(ii) Conduct inventories of properties that will be affected in coordination with the Detailed Design Consultant;

(iii) Prepare parcellary maps of the project area in coordination with the Detailed Design Consultant;

(iv) Approve disbursement vouchers/payments on PAFs compensation and other benefits;

(v) Submit disbursement reports on payments to PAFs to the Regional/Central Office accounting office and PJHL-PMO;

(vi) Submit monthly progress reports to ESSD, Regional Office and PJHL-PMO; and

(vii) Serve as an active member of the Resettlement Implementation Committee (RIC) of the City/Municipality.

13.12.5 Regional Office (Region XI) of DPWH

The Regional Office shall act as the liaison between ESSD, ROWO and the District Engineering Offices and shall ensure that the RAP is implemented as planned. Its specific activities include:

- Oversee the activities of DEOs;
- Monitor the RAP implementation and fund disbursement;
- Submit monthly progress reports to ESSD;
- Monitor payments to PAFs; and
- Address grievances filed at its office by the PAFs for speedy resolution.

13.12.6 City Resettlement Implementation Committee (CRIC)

The CRIC shall be composed of representatives from the Regional Office and District Engineering Office, the City/Municipality LGUs, affected barangays, and PAFs/PAPs. No NCIP or ICC/IP representatives are included in the RIC as no recognized ancestral land will be affected by the project alignment. The establishment of the RIC shall be made through the signing of MOU between DPWH and the concerned LGU. The function of the RIC includes:

(i) Assist the project consultants and DPWH staff engaged in RAP preparation activities in (a) validating the list of PAFs; (b) validating the assets of the PAFs that will be affected by the project; (c) assist DPWH in arranging for a suitable relocation facility for the displaced PAFs, and (d) participate in monitoring the RAP implementation;

(ii) Assist the DPWH staff engaged in the RAP preparation in the public information campaign, public participation and consultation meetings;

(iii) Receive complaints and grievances from PAFs and other stakeholders and refer the matter to the appropriate authorities;

(PCUP).

(iv) Maintain a record of all public meetings, complaints and actions taken to address complaints and grievances; and

(v) In coordination with concerned government authorities, assist in the enforcement of laws/ordinances regarding encroachment into the project site or ROW.

13.12.7 Local Inter-Agency Committee (LIAC)

To streamline acquisition of needed ROW and at the same time be compliant with international policies on involuntary resettlement together with the DPWH's own resettlement policy, roles, responsibilities, and efforts of key players and major stakeholders must be well coordinated. In order to achieve this, it is strongly recommended that, a LIAC, which will be based in Davao City be organized.

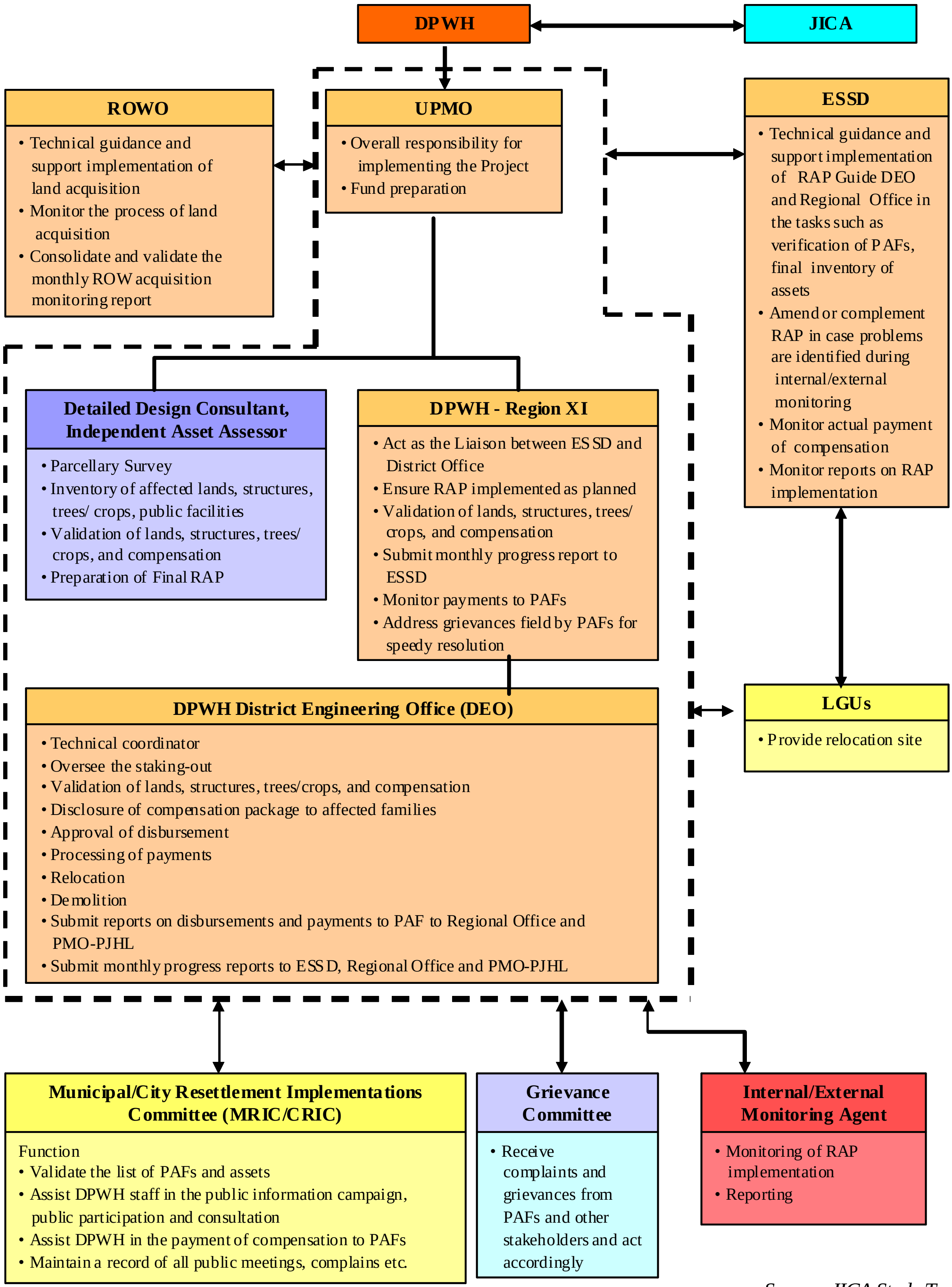
The LIAC will help ensure that a common direction is being followed to achieve the goals of the RAP. Provided in **TABLE 13.12-1** is a list of said key players and major stakeholders and their corresponding responsibilities.

TABLE 13.12-1 KEY PLAYERS AND MAJOR STAKEHOLDERS FOR RAP IMPLEMENTATION

Key Player	Key Person	Position in LIAC	Envisaged Role
DPWH UPMO	UPMO Director	Chairperson	Provide direction with regards to implementation of the Davao City Bypass Construction Project (DCBCP)
DPWH ESSD	ESSD Chief	Member	Provide direction with regards to implementation of the RAP for DCBCP
DPWH IROW	IROW Director	Member	Provide direction with regards to DPWH ROW acquisition procedures in relation to RAP implementation
PHILCOA	As deemed appropriate by Agency	Resource Person	Provide guidance regarding technical and other aspects of coconut plantations, particularly when it comes to cutting of trees and transport of coconut lumber
Department of Agriculture (Bureau of Plant Industry)	As deemed appropriate by Agency	Resource Person	Provide guidance regarding technical, economic, and other aspects of banana plantations and other crops classified as agricultural and industrial
Davao City City Housing Board or Equivalent Office	As deemed appropriate by LGU	Member	Provide information and guidance regarding access to socialized housing projects of the City
Major Stakeholders			
LGU of Davao City	City Mayor, City Agriculturist, Livelihood Office	Members	Represent the PAPs of Davao City
LGU of Panabo City	City Mayor, City Planning, Development Coordinator	Members	Represent the PAPs of Panabo City

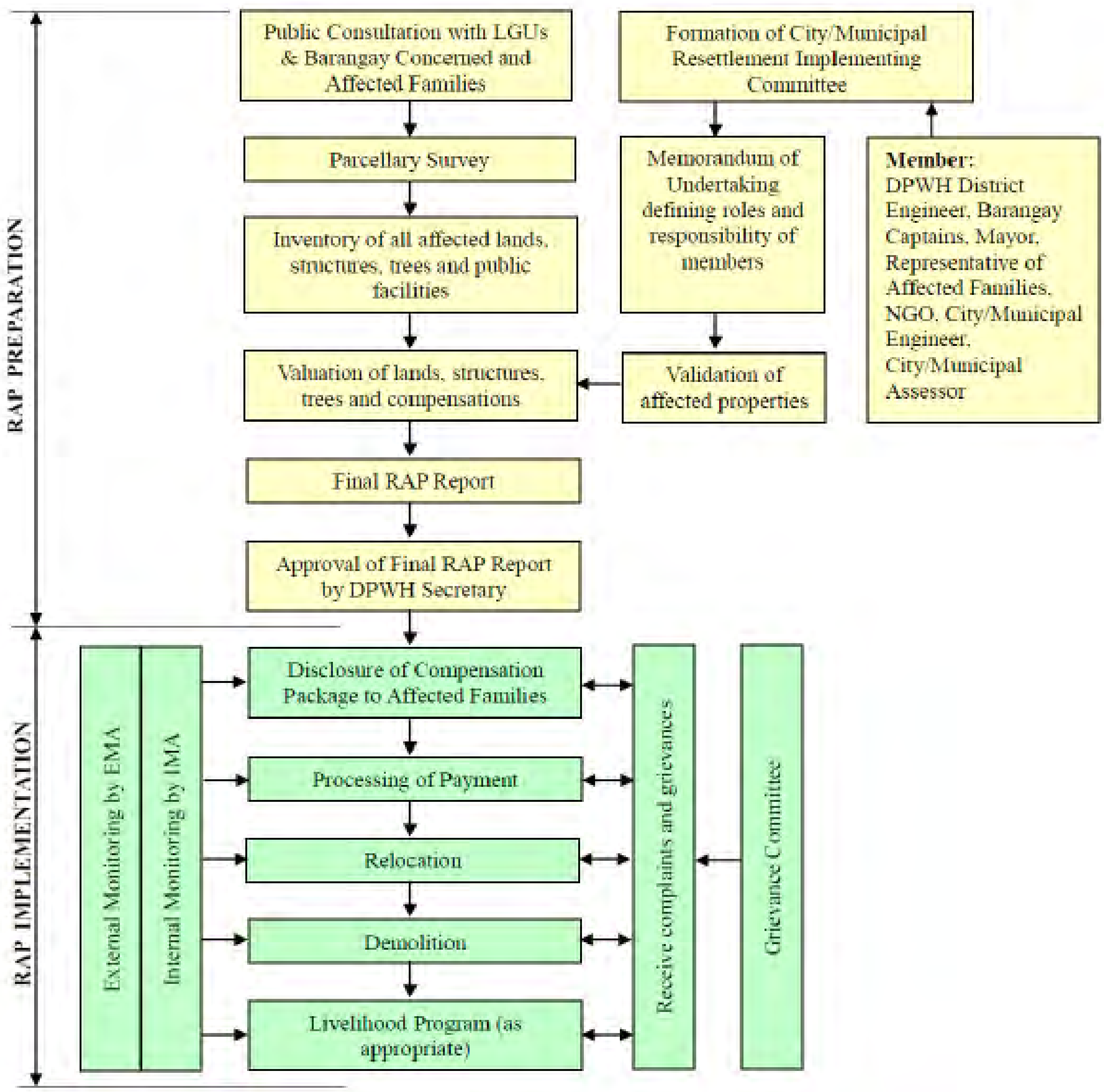
Source: JICA Study Team

The RAP implementation organization and process are illustrated in **FIGURE 13.12-1** and **FIGURE 13.12-2**, respectively.



Source: JICA Study Team

FIGURE 13.12-1 RAP IMPLEMENTATION ORGANIZATION



Source: JICA Study Team

FIGURE 13.12-2 RAP Implementation Process

13.13 CONSULTATION AND PUBLIC PARTICIPATION

13.13.1 Content of Consultation Meetings

PAFs must be fully informed at the earliest possible time. They should be closely consulted and encouraged to participate in any decision-making pertinent to resettlement. Project disclosure and consultation at an early stage provides a good venue for PAFs to express their opinions, apprehensions, and even objections. It opens grounds for discussion, and allows the Implementing Office to address issues raised, most of which can be incorporated into the final design and resettlement plan. This will minimize, if not totally avoid, delay in implementation caused by unforeseen stand-offs.

Consultation meetings shall be conducted at site with the stakeholders. One at least is prior to the preparation of the RAP and others are after. **TABLE 13.13-1** shows a standard example activity for consultation meetings to be conducted including future disclosures to be undertaken.

TABLE 13.13-1 ACTIVITES FOR CONSULTATION MEETINGS

Frequency	Milestone and Purposes
1st Disclosure	Prior to Preparation of RAP a. To inform the PAPs about: i) the activity to be undertaken during rehabilitation/improvement of the road/bridge; ii) the expected adverse impacts such as displacement of households; iii) that there will be validation after the detailed design to finalize number of PAPs to be affected; iv) the no-worse off policy of JICA and World Bank; and v) the explanation of cut-off date and its announcement b. To encourage PAP's to express their ideas, concerns and apprehensions, and other related issues.
2nd Disclosure	After Preparation of RAP a. To inform the PAPs and other stakeholders about the RAP; b. To ask the PAPs to review the RAP; c. To ask the PAPs to give their comments/objections on the RAP; and d. To inform the PAPs that a Resettlement Action Plan Implementation Committee shall be formed and that they should choose (a) representative(s) who would be (a) member(s) of this entity.

13.13.2 1st Disclosure Meeting

The 1st disclosure meetings (public consultation) were held on June 16 to 19, 2014 at six venues through the designed alignment. Basic information such as date/time/venue, barangays included and participant composition is shown in **TABLE 13.13-2**, and typical Q&A, comment, note and information are in **TABLE 13.13-3**, respectively.

TABLE 13.13-2 BASIC INFORMATIONON THE 1ST DISCLOSURE MEETING

No.	Date, Time & Venue	Sub-District/Barangay	Participants
1	June 16, 2014, 2:00 PM Marapangi Brgy. Hall, Torril, Davao City	Alambre, Bangkas Bato, Heights, Lubogan, Marapangi, Mulig and Sirawan,	27 males & 20 females (LGU & Brgy official, landowner, possible PAP, industry, farmer, etc.)
2	June 17, 2014, 9:00 AM Tigatto Brgy. Hall, Buhangin, Davao Hall	Tigatto and Waan	14 males a& 3 females (LGU & Brgy official, landowner, possible PAP, industry, farmer, etc.)
3	June 17, 2014, 2:00 PM Cabantian Brgy. Hall, Buhangin, Davao City	Cabatian, Communal and Indangan	12 males & 5 females (LGU & Brgy official, landowner, possible PAP, industry, farmer, etc.)
4	June 18, 2014, 9:00 PM Mahayag Brgy. Hall, Bunawan, Davao City	Lasang, Mahayag, Mudiang, San Isidro and Tibungco,	16 males & 18 females (LGU & Brgy official, landowner, possible PAP, industry, farmer, etc.)
5	June 18, 2014, 2:00 PM J.P. Laurel Brgy. Hall, J.P. Laurel, Panabo City	J.P. Laurel	2 males & 2 females (LGU & Brgy. Official, landowner)
6	June 19, 2014, 9:00 AM Mintal Brgy. Hall, Tugbok, Davao City	Matina Biao, Mintal, Tacunan and Tubok Proper	52 males & 36 females (LGU & Brgy official, landowner, potential PAP, industry, farmer, etc.)

TABLE 13.13-3 SUMMARU OF TYPICAL Q&A, COMMENT, NOTE AND INFORMATION DURING THE 1ST DISCLOSURE MEETINGS

About Project

Attribution	Venue	Question/Comment	Response
Possible PAP	Marapagi	What benefit can the farmers get from the bypass road project?	The bypass will affect the economy of the areas that will be traversed positively by bringing development or improving urbanization and land values of remaining portions will have higher appraisals.
		How true was the rumor that JICA is assisting DPWH with a purpose of locating the buried treasures in the area?	The rumor was proved to be wrong because JICA is an association providing financial assistance to countries through loan just like the World Bank and ADB. Also, JICA does not pay for the land acquisition on the right of way. Only the GoP can acquire rights to land acquisition for road projects.
Possible PAP	Tigatto	Need to clarify the location of the tunnel section.	Tunnel section will only be at Matina Biao and Magtuod areas.
Brgy. official		How will this project affect the existing flood problem in Brgy. Tigatto?	Mitigating measures for flood problems on the affected areas will be considered. The data that will be gathered will be noted in designing the drainage of the bypass. However, the drainage design of the bypass will not be intended to control the existing flood problems in the area, rather it will be designed to prevent aggravating the existing flood problems.
Brgy. captain	Cabantian	On tunnel section, will the GoP pay for the land even if the road will only be built passing through the mountain?	If land owner wants to be paid even if they're not directly affected, the GoP will compensate them for their property and the land owner has to leave their area as it will become a government property or they can negotiate to be compensated a percentage only of the land since the road will be constructed 200m from the ground surface. The Study Team explained the new supreme court ruling on land ownership.
Brgy. official		I emphasize a point for the benefit of the land owners that they cannot name a high value for their property if what has been declared to the BIR is actually lower than that of claimed.	Lot owners can still demand for a higher valuation if they have supporting documents to prove their claim through the expropriation procedure.
Landowner	Mahayag	Will alignment still change?	There are still possible changes in the alignment during the detailed engineering design.
Industry (Holcim)		The alignment will most likely affect the mine life of Holcim for the next five years, if detailed engineering design is available, Holcim can coordinate with the DPWH to design an alignment that would not affect the mine life of Holcim.	JST already visited the Holcim office to set a meeting schedule for discussion on the project's development plans with the company.
		We suggest to change the alignment towards areas of Holcim that is almost mined out and due for rehabilitation (existing quarry area) to avoid areas of future (3-5 years) mine development.	Suggestion will be discussed with the JICA study team.

Attribution	Venue	Question/Comment	Response
Landowner	Panabo City	How far is the proposed bypass from the existing bridge in JP Laurel?	Approximately 200m from Lasang bridge.
		Is it possible for the existing building to be affected by the bypass?	The proposed bypass will not affect the existing building as it will only traverse on the banana plantation beside the clearing.
Landowner	Mintal	What is the purpose of the bypass when there are already existing barangay roads? Furthermore, farmers with small properties will be greatly affected by this project.	Bypass will be constructed to help mitigate traffic congestion on major roads within the city proper and development of the rural areas.
Possible PAP		Will there be a road constructed on the top of the mountain?	There will be no road to be constructed on the top of the mountain, only through the mountain which will be 200meters from the mountain's surface.

Compensation

Attribution	Venue	Question/Comment	Response
Farmer	Marapagi	How will the farmers be compensated with the crops that were bought on credit from PCA?	The crops that will be affected by the project will be compensated by the GoP.
Brgy. captain	Cabantian	Suggests that DPWH should consider compensating for the land based on the market value on the year when the government would acquire the land and not based on the value when the owner had bought their property.	The Provincial Appraisal Committee, if requested by DPWH will update valuation of lands. As a government agency, all DPWH payments require approval from Commission on Audit (COA). COA requires that current prevailing market value should have supporting documentary evidence. Suggests that transactions on land acquisition should be declared to BIR based on the actual transacted value to support the claims on current prevailing market value.
Possible PAP		Will the GoP also pay for the agricultural products on the affected lands?	Aside from structure compensation, there will also be compensation for agricultural and industrial products on the affected land areas.
Landowner	Mintal	Will there be compensation for structures and crops?	There will be compensation to crops and structures that will be affected by the project. For farmers with small properties, JST will suggest on the RAP development for assistance in finding a replacement land for farming considering PAP's desires.
		Structure was built by home owner, who will be compensated for the structure?	The home owner will be paid for the loss of structure and land owner will pay a waiver of rights to structure compensation.

Land Issue/Relocation

Attribution	Venue	Question/Comment	Response
Possible PAP	Marapagi	The tenant had constructed a structure on the area that will be affected by the bypass, who will be held responsible for the replacement of the house/structure?	The tenant will be paid by the GoP and the land owner will sign a waiver that he/she will not have any hold on the payment.
		Need to know basis for land valuation on land acquisition.	The GoP will first offer the BIR Zonal as basis for land valuation.

Attribution	Venue	Question/Comment	Response
		Need to clarify whether the property will be affected or not as there was no survey conducted on their property.	If the land owner received an invitation to the meeting, there is a probability that their property will be affected by the project. Any future changes on the alignment will be communicated to the locals.
Possible PAP	Tigatto	Are there any specific areas as to where the bypass will traverse?	At present, as the invited land owners are the possible PAPs of the project, we can only identify the specific land areas that will be affected during the detailed engineering design on the conduct of parcellary survey.
Brgy. official		Which office can the land owner approach if he/she wants to suggest for their land to be traversed by the bypass?	This can be suggested during the detailed design where the exact alignment will be finalized. However, we should note that there are safety measures that needs to be considered in conducting the detailed engineering design, example road curve shouldn't be a sharp curve for safety purposes
		Hopefully the government will not ask the land owners to donate their land for the project as some land owners that owns only small parcels of land in the area.	Donation as part of the GoP's way of land acquisition for development has been included for transparency. Also there are cases when land owners would offer to donate their lands to the government for development purposes. Land owners with big parcels of land will be requested first to donate some portion of their lands for the project. However, if they would not want to donate their lands, they will be compensated for the parcel of land that will be used for the project. As for those who owns a small parcel of land, they will most likely be by negotiation instead of donation.
Landowner		How long would it take for the land owners to be informed if their properties will be affected by the bypass?	The final list of land owners that will be affected by the project will be determined during the parcellary survey which will be conducted after the detailed engineering design. The detailed engineering design is estimated to be conducted after the bilateral agreement. The final list of land owners will be invited on a meeting after the parcellary survey.
Landowner	Cabantian	If land owners would say 'no' to the project, will the project still push through?	As discussed, the last option that the GoP will take is the expropriation procedure because based on the constitution. The government can take any property for public use with negotiation and compensation.
Representative of Christian society		Are lot owners not allowed to make development on their properties since now?	Private land owners have all the rights to develop their lands.
Landowner		Wish to know about lot owner's assurance that they can still find a similar land to develop as replacement to the land that will be lost.	There is no land for land replacement on the present law. However the team will commit to do their best to recommend for this arrangement for the benefit of PAPs with small properties.
Possible PAP	Mahayag	If property is only $300m^2$ and bypass project will have to use $250m^2$ of the land, can the government just buy the entire lot instead of leaving a $50m^2$?	In accordance with the DPWH LARRIPP, the GoP will buy the entire lot if remaining portion will not be economically viable.
		If land owners will be compensated, how much of the total value will be left for the land owners as there are some taxes that also needs to be	Land owners will be paying for the Capital gain tax, documentary stamps and transfer tax will be paid by DPWH.

Attribution	Venue	Question/Comment	Response
		settled during land acquisition?	
Brgy. official		Which zonal value will be considered for land valuation?	BIR Zonal Value is.
		Very few land owners would sell their land at a very low price, how will they be able to justify this during the negotiation for land valuation?	If land owners have complete legal document that would help support their claims of high land valuation in the area.
		Communities sell their land for a higher value than that of the BIR Zonal Value.	BIR Zonal value is the first offer for land acquisition. Land owners can demand for a higher valuation provided that they have legal documents supporting their claims, during expropriation proceedings.
Brgy. captain		Need to clarify land valuation: if there are discrepancies on deed of sale are there any other basis for land valuation?	The land appraiser will study cases of land valuation to determine the right market value of the land, there will be other basis for land valuation aside from the deed of sale.
Landowner		The property has been converted to Home Owners Association, and some residents have already fully paid the lot area. However the land is still under the name of husband of the person asking, who then will be compensated in the future?	The team suggests that in order to avoid future disputes on land compensation, the land owner should start sub-dividing the lot title to individuals that had fully paid their land. As for the structure, if the home owners built the structures in the area the land owner will sign a waiver of rights to structure compensation.
Landowner	Mintal	Need to know modes of payments to land owners.	Modes of payments to the land owners whether the land is vast or small will be the same, except in cases when big landowners want to donate land.
		Can land owners be compensated if the proof of ownership is only Deed of Sales (DOS)?	Yes, DPWH recognizes the DOS and titled lands.
		If land owner suggests to relocate the home owner within the property of the owner instead of relocating them to the relocation site, is it possible?	If home owner agreed to the suggestion of the land owner, then it's possible.
		How did the group acquire the names of lot owners as the names listed are of those previous owners?	The real land owners will be determined after the parcellary survey. There really are some records in the assessor's office wherein the current land owner's names does not reflect, but the real land owners will be most likely determined after the conduct of parcellary survey.
		About entitlements of renter, buyer and agricultural lessee	Just compensation is entitled to land owners. Renter, tenant and agricultural lessee will receive a financial assistance from the government.
Possible PAP		Lot was sold to a new owner, can new owner be invited to the next meeting instead of the previous land owner?	JST notes the fact.
Industry (Plantation)		Will there be compensation for the land preparation?	Yes, there will be compensation for the land preparation.

Livelihood Restoration

Attribution	Venue	Question/Comment	Response
Possible PAP	Marapagi	What is effect of the bypass on livelihood of local farmers?	The GoP will be providing assistance to the PAPs; a survey will be conducted to identify the types of livelihood of PAPs which will need such assistance from the government as mandated by law.
Brgy. official	Tigatto	Will there be job opportunities for the locales?	As mandated by the law all affected barangays, especially a family member of the directly affected land owners will be the priority for employment during construction.
Possible PAP	Mintal	Rights of Indigenous people on areas affected by the project.	There is no ancestral domain that would be affected by the project as confirmed by the NCIP Davao City Office.
		I concern compensation for opportunity loss.	There will be no compensation for opportunity loss.
Industry (Plantation)		We concern income loss after crop land provision.	There is no law to compensate for income loss, only for the agricultural and industrial crops at present.

Note/Information

Attribution	Venue	Question/Comment	Response
Brgy. captain	Cabantian	Clarified for the benefit of the land owners that the property owner cannot say no if their property will be needed by the government for public use.	The survey team noted the comment.
Brgy. official		Suggests to have an intensive information dissemination for the PAPs so that PAPs will understand that this government project is for the development of their area and that land owners would not be surprised of the processes that the government might be taking in the future.	The team explained the main purpose of conducting the meeting is to properly inform the affected community of the project and processes that the government will be taking into consideration - in line with the national laws as part of developing the project.
Representative of Christian society		Ambassadors for Christ is planning to extend church building.	The team notes it.
Landowner	Panabo City	I express that the project is a good plan for development.	JST notes the comment.

Basic policy for compensation and livelihood restoration was explained during the 1st disclosure meetings. In the 2nd meetings to be held in Oct 2014, the Study Team will show the results of socio-economic survey and concrete plan for compensation and assistance to brush up based on opinions from the PAPs.

13.14 GRIEVANCE REDRESS MECHANISM

If there will be grievances arising from any aspect of the Project, these will be handled through negotiations following the succeeding procedures.

In accordance with the LAPRAP Tracking Manual of DPWH, a Grievance Handling Committee (GHC) shall be formed within the City/Municipal Resettlement Implementing Committee (CRIC/MRIC-GHC) to facilitate the resolution of the PAPs' grievances. The CRIC's/MRIC's Chairperson shall head this Committee. Each representative from concerned barangay government shall be his Co-Chairperson(s). The GHC shall consist of the following:

(i) Legal Officer from the Legal Service (DPWH Central);

(ii) IROW Engineer;

(iii) IROW Agent;

(iv) Land Management Section Chief/Representative (DENR Regional/Provincial Office);

(v) City/Municipal Assessor;

(vi) Community Environment and Natural Resources Officer (CENRO);

(vii) RP Preparer (from DPWH-UPMO their Consultant);

(viii) Representatives of PAPs; and

(ix) Representatives of NGOs

This procedure is initiated once the letters from PAFs, expressing their grievances are received by the CRIC-GHC. The deadline for submitting letters of grievances shall be set 30 days after the date of public disclosure; with a maximum extension of another 15 days, if request was made by more than ten percent (10%) of the PAFs.

A Grievance Action Form (GAF), as prescribed in the said LAPRAP Tracking Manual shall be used during the detailed design stage to cover the various aspects of property acquisition based on validation of the RP. The GAF shall, at the very least, contain the following:

(i) Basic information on PAPs (Name, Address, Contact Number);

(ii) Date of last disclosure meeting;

(iii) Category of grievance filed (Legal, Technical/Engineering, Social, and Financial); and

(iv) Type of action taken (Resolved at the CRIC level, or referred to higher authorities.

Respective barangay captains, as co-chairperson of the GHC shall be the first recipient of the GAF. All GAFs shall be consolidated by the CRIC/MRIC chairperson and presented to the CRIC/MRIC for deliberation and appropriate action, on a weekly basis. Unresolved grievances at the CRIC/MRIC level shall be elevated to the respective District Engineering Offices for resolution of complaints. Recommendations of the District Engineer shall be elevated to the Regional ESSD for approval and final action. If there are still unresolved grievances, a case shall be filed in the proper courts.

PAPs shall be exempted from all administrative and legal fees incurred in pursuant to the grievance redress procedures.

13.15 IMPLEMENTATION SCHEDULE

13.15.1 Tentative Implementation Schedule

Implementation of RAP Activities is presented in **TABLE 13.15-1**. Note that timing of the first disclosure shall take place upon completion of the Parcellary Survey. During updating of the RAP actual measurements of structures in the field must be undertaken to have more accurate basis for compensation. In addition it is also during updating of the RAP when target relocation sites are inspected and assessed in terms of acceptability and potentials for sustainable livelihood (i.e., if the affected renters of private land would opt to be resettled).

TABLE 13.15-1 SCHEDULE FOR IMPLEMENTATION RAP ACTIVITIES

Activity	Year 1 (2014)				Year 2 (2015)				Year 3 (2016)				Year 4 (2017)		
	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q	1Q	2Q	3Q
First Disclosure															
Parcellary Survey															
Updating of RAP															
Validation of PAPs and Entitlements															
Approval of the Updated RAP															
Formation of the CRIC/MRIC															
Disclosure of Updated RAP to PAPs															
Notification of PAPs															
Compensation															
Provision of Replacement Land (OPTIONAL)															
Relocation to Replacement Land (OPTIONAL)															
Income Restoration															
Approval of Road Design															
Finalization of the RAP															
Commencement of Civil Works															
Monitoring & Evaluation															
Internal Monitoring															
External Monitoring & Evaluation															

13.16 COST AND BUDGETS

13.16.1 RAP Implementation Budget

(Confidential)

13.17 MONITORING

In accordance with D.O. 58 of DPWH, ESSD shall be responsible for conducting the in-house monitoring of implementation of the RAP and IPAP (for affected IPs outside the ancestral domain) , and as such shall be alternately referred to as the Internal Monitoring Agent (IMA). Tasks of the IMA include:

(i) Regular supervision and monitoring of the RAP implementation in coordination with concerned Regional Offices (ROs), DEOs, and RICs. Finding are documented in a quarterly report and shall be submitted to the IO/PMO;
(ii) Verifying whether the re-inventory baseline information on all PAPs have been carried out and whether the valuation of assets lost or damaged, provision of compensation and other entitlements, and relocation, if any, have been carried out in accordance with the respective RPs and the LARRIPP;
(iii) Ensuring that the RAP and IPAP are implemented as designed and planned;
(iv) Verifying that funds for implementing the RAP, MOAs, and IPAPs are promptly provided by the IO/PMO and in sufficient amounts; and
(v) Recording all grievances and their resolution and ensuring that all complaints are promptly addressed.

To obtain an independent appraisal of the RAP implementation, an independent External Monitoring Agent

(EMA) shall be commissioned by the DPWH-UPMO to undertake monitoring and evaluation. The EMA can either be a qualified individual or a consultancy firm with qualified and experienced staff. Prior to engagement, DPWH shall submit to JICA for its concurrence, the Terms of Reference for the EMA. The tasks of EMA generally consist of:

(i) Verifying the results of internal monitoring (i.e., undertaken by ESSD);
(ii) Verifying and assessing the results of the information campaign for PAPs' rights and entitlements; Verifying that the compensation process has been carried out in accordance with procedures communicated with the PAPs during consultations;
(iii) Assessing whether resettlement have been met, particularly with regards to livelihood and restoration and/or enhancement of living standards;
(iv) Assessing the efficiency, effectiveness, impact and sustainability of resettlement and implementation, drawing lessons as a guide to future resettlement and policy making and planning;
(v) Establishing whether the resettlement and entitlements were appropriate to meet the objectives, and whether these objectives were appropriate to PAP conditions;
(vi) If necessary, recommending modifications to the implementation procedures of the RAP, to achieve the principles and objectives of JICA guideline, and the DPWH's LARRIPP;
(vii) Reviewing how compensation rates were established; and
(viii) Reviewing whether compliance and grievance cases were properly handled

CHAPTER 14
OPERATION AND MAINTENANCE OF THE PROJECT

14.1 TUNNEL O & M

14.1.1 O & M activities for Tunnel

Major O & M activities are classified as follows;

MAJOR O&M ACTIVITIES

1) Inspection
2) Routine Maintenance; tunnel structure and facilities
3) Monitoring of traffic movement, traffic accident, fire incident, etc.
4) Immediate actions when some incidents are found or reported
5) Vehicle Control (vehicles carrying hazardous materials, vehicle height, and overloaded trucks.

(1) Inspection

Inspection of a tunnel must be undertaken daily by an inspection team, and check the following:

- Facilities inside the tunnel such as lighting facility, jet fans, etc. are properly functioning.
- Cleanliness of the tunnel wall, facilities, etc.
- Any cracks on concrete lining and pavement, water seepage from concrete lining, etc.
- Drainage facility (no clogging, etc.)
- Deformation of the tunnel arch.
- Any other problems.

(2) Routine Maintenance

- Cleaning of tunnel structure and facilities (tunnel wall, road surface, facilities inside a tunnel.
- Crack Ceiling
- Replacement of tunnel facilities which are not functioning

(3) Monitoring traffic movement, traffic accident, fire incident, etc.

This work must be undertaken for 24-hours a day for 365 days a year. Traffic movements are monitored through CCTV, report from a patrol group and road users. Information shall be compiles at a traffic control center of the Tunnel Management Office, and necessary actions shall be quickly decided and informed to proper agencies and action team.

Monitoring will be focused on the following:

- Reckless driving
- Overtaking
- Over speeding
- Stopped (stalled)/parked vehicles
- Vehicle breakdown

- Obstacles dropped from vehicles
- Accident
- Fire

Information collected shall be properly recorded and necessary information shall be provided to road users through Variable Information Signboards and a Loudspeaker.

Monitoring is quite important to assure safe operation of a tunnel and to protect road users' lives.

Emergency actions shall be made in accordance with the instructions of the head of the monitoring team.

(4) Immediate Actions when some incidents are found or reported

The head of the monitoring team shall immediately decide what to do when some incidents are found or reported from road users. He must decide whether a case must be informed to Action Team, Fire Department and/or Police.

Major incidents are as follows;

- Traffic accident
- Fire
- Vehicle breakdown
- Obstacle dropped from vehicles
- Parked/stopped (stalled) vehicles

Actions to be taken during emergency cases are illustrated in **Figure 14.1-1.**

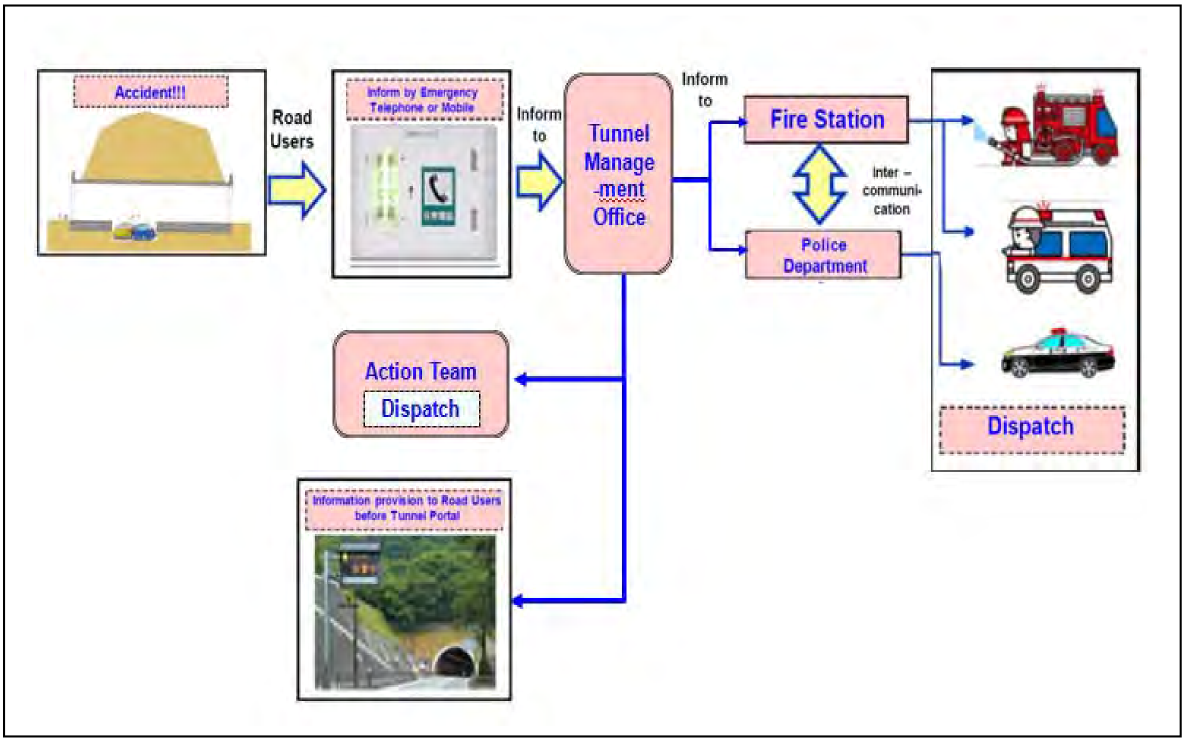


FIGURE 14.1-1 ACTIONS TO BE TAKEN DURING EMERGENCY

(5) Vehicle Control

The following vehicles should be controlled to pass through the tunnel;

- Motorbikes
- Tricycles
- Vehicles carrying hazardous materials
- Overloaded trucks
- Vehicles of which height is higher than the limit

14.1.2 O & M Organization of Tunnel

In order to assure safe operation inside a tunnel and to save road users' lives in case of critical incidents, the "Tunnel Management Office" must be established. The proposed structure of Tunnel Management Office is shown in **Figure 14.1-2.**

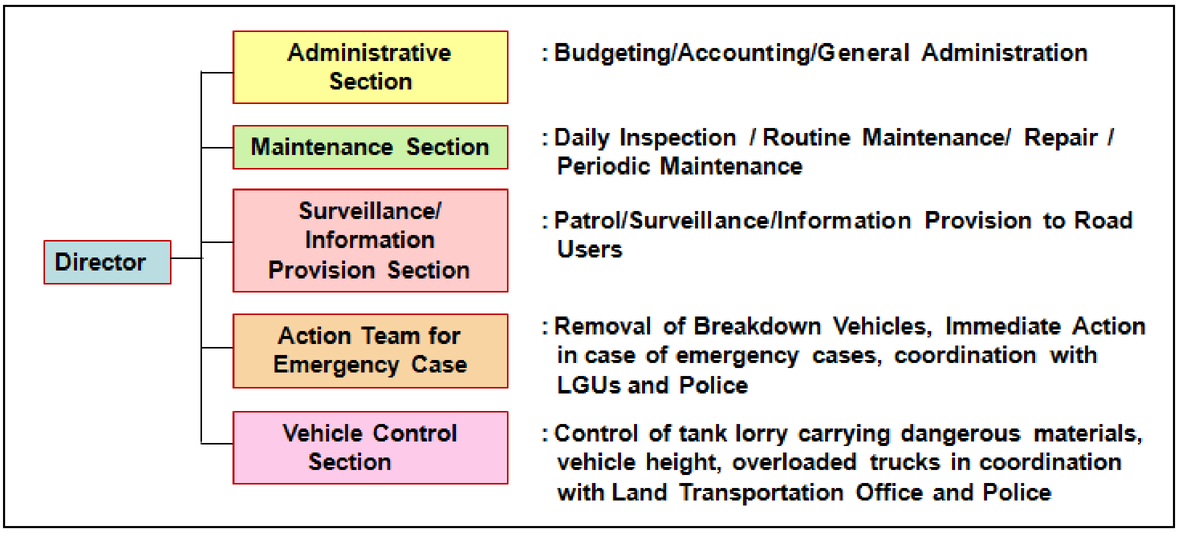
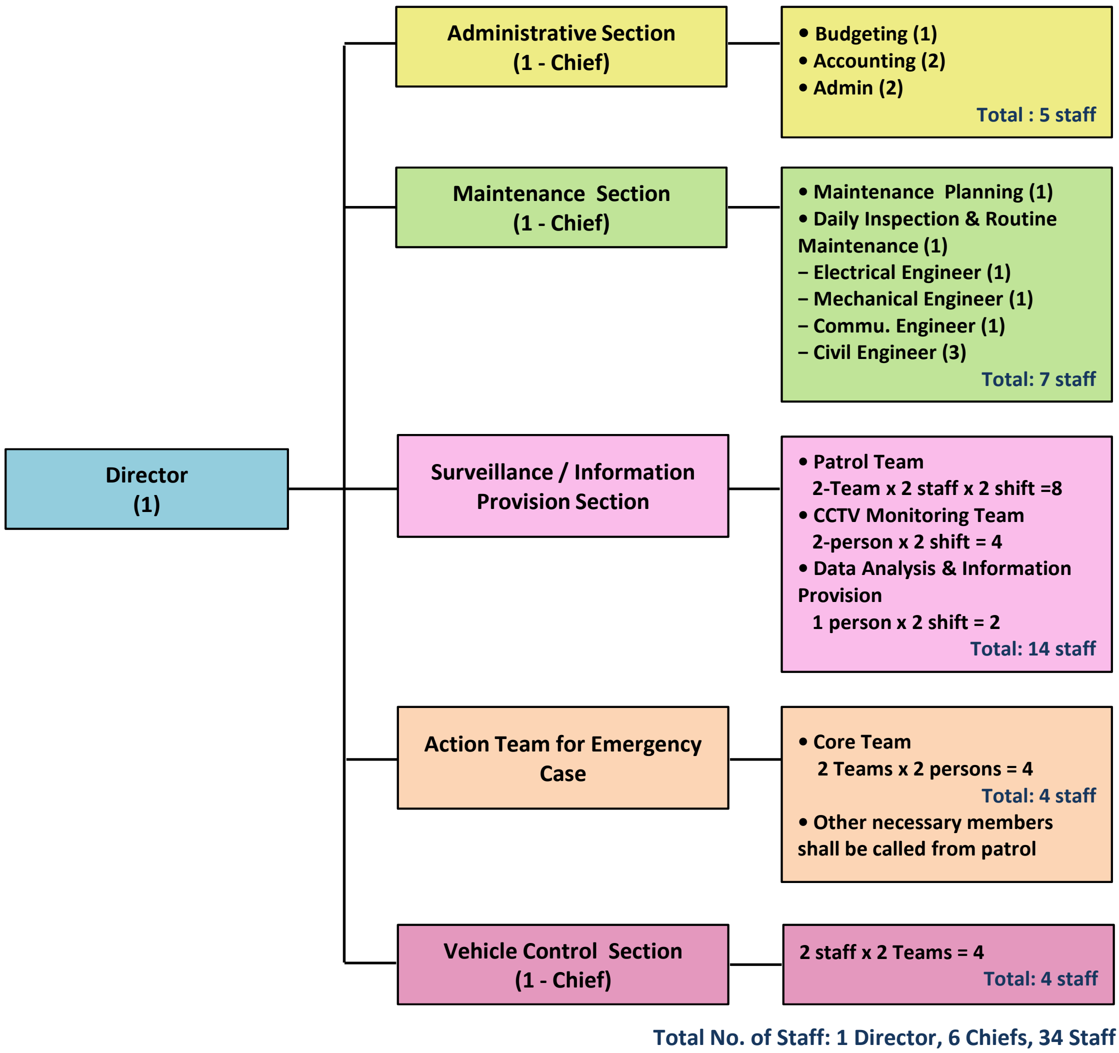


FIGURE 14.1-2 PROPOSED ORGANIZATION OF TUNNEL MANAGEMENT OFFICE

If a toll is collected to produce fund for tunnel O & M cost, Toll Collection Section must be organized.

Number of staff required will be forty one (41) comprising of one (1) director, six (6) chiefs and thirty four (34) staff as shown in **Figure 14.1-3.**



Source: JICA Study Team

FIGURE 14.1-3 ESTIMATED HUMAN RESOURCES

14.1.3 O & M Cost Estimate

(Confidence)

14.1.4 Fund Source for Tunnel O & M Cost

Relatively a large amount is required for tunnel O & M. The following two fund sources can be considered;

Case-1: MVUC + GAA
Case-2: A toll is charged to tunnel users

The above two cases will be studied and optimum fund source will be recommended.

CHAPTER 15
PROJECT IMPLEMENTATION PLAN

15.1 IMPLEMENTATION STRATEGY

Davao City Bypass has three sections, namely South Section, Center Section and North Section.

The estimated Construction Cost and ROW Acquisition Cost are as follows.

(CONFIDENTIAL)

The study of implementation priority of the Davao City Bypass was conducted (see section 15.2) then the Survey Team find out the South Section and the Center Section will have more urgent need for implementation, while the North Section can still accommodate some more traffic.

It is suggested that the **South and Center Section shall be the Project Section by Japan's ODA Loan** and later on the North Section by local fund.(see **Figure 15.1-1**)

(CONFIDENTIAL)

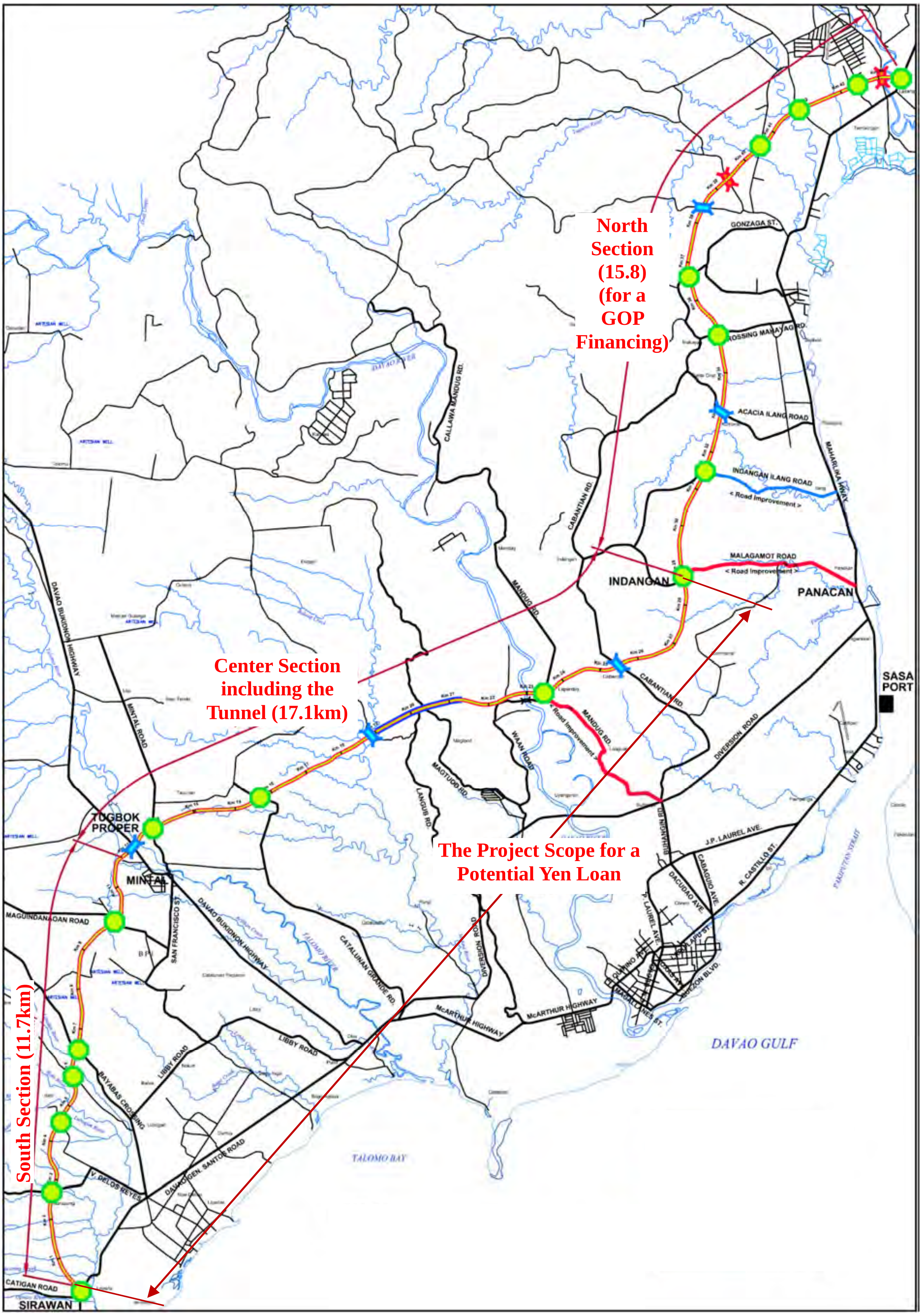


FIGURE 15.1-1 PROJECT FINANCING BY SECTION

15.2 STUDY OF IMPLEMENTATION PRIORITY OF DAVAO BYPASS SECTION

1) Objective of Package Study

- Estimated Cost based on the Preliminary Design is a huge amount of 11.54 Billion Php.
- It is necessary to acquire the 60m RROW of 44.58km (approx. 2,500,000 sq.m.)
- The Bypass was divided into three (3) sections (South 11.7km, Center 17.1km and North 15.8km)
- Which sections have implementation priority and has greater impact for initial stage?

2) Case Study

- The following four cases were studied: (see **Figure 15.2-1**)
  - Case-1 Center Section (including Tunnel portion)
  - Case-2 South and Center Section (including Tunnel Portion)
  - Case-3 North Section
  - Case-4 Whole Section

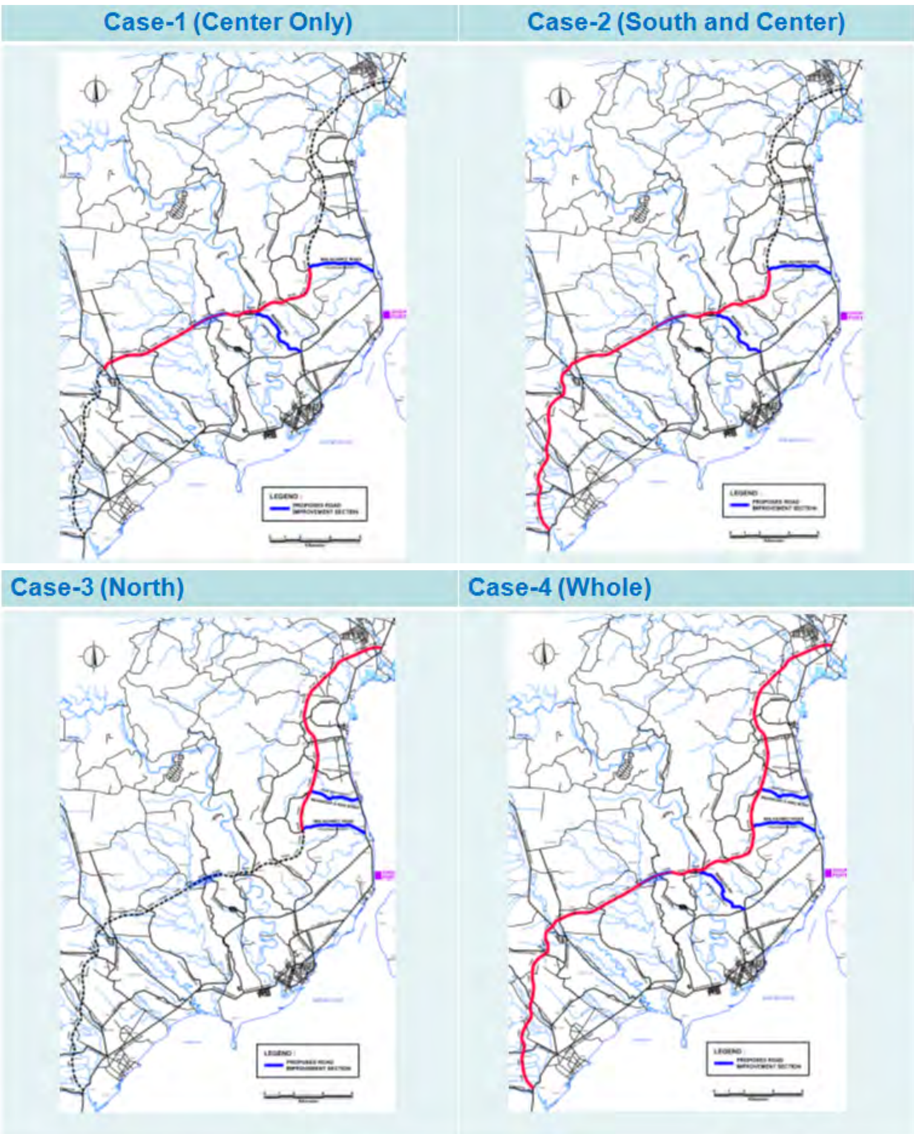


FIGURE 15.2-1 CASE STUDY MAP OF DAVAO BYPASS IMPLMENTATION PRIORITY

3) Case Study Result

Based on the Case Study Results, Case-2 (South Section and Center Section) is the most urgent needs for Implementation.

TABLE 15.2-1 CASE STUDY RESULT

	Case-1	**Case-2**	**Case-3**	**Case-4**
Bypass Section	**Center (Tunnel)**	**Center + South**	**North**	**Whole**
Bypass Length (km)	17.0	28.8	15.8	44.6
Const. Cost (Bil.Php)				
Const. Cost per km (M.Php)				
Impact of major Improvement	Davao-Bukidnon Road from/ to Sasa Port and Davao Poblacion access will be improved (O)	Davao-Bukidnon Road and Digos, south of Davao from/ to Sasa port and Davao Poblacion access will be improved (◎)	Davao North area from/ to Sasa Port and Davao Poblacion access will be improved (△)	Davao-Bukidnon Road , Panabo and Digos, south of Davao from/ to Sasa Port and Davao Poblacion access will be improved (◎)
Traffic Attracted Y2018 (veh./day)	5,600 (O) (at Tunnel)	6,500 (◎) (at Tunnel)	3,100 (△)	6,700 (◎) (at Tunnel)
Total Travel Time Reduction (Veh*hr. day)	5,511	11,581	1,105	15,125
EIRR (>15.0%)	12.7% (×)	20.7% (◎)	1.7% (×)	18.8% (O)
Social Impact. No. of affected Structures	46 (O)	69 (O)	37 (◎)	106 (△)
Japan's Technology	Tunnel Const. (O)	Tunnel Const. (O)	Not Necessary (×)	Tunnel Const. (O)
Evaluation	3rd	**1st Recommended**	4th	2nd

4) Recommendation

- **<u>Case-2 (South and Center Section) is the best scheme</u>** for the initial stage of Bypass Construction.
- South and Center Sections can have efficient bypass function as traffic going from/to Sasa Port and Urban Center can avoid to pass through the urban center.
- Since Daang Maharlika Highway of North Section can still accommodate some more traffic, implementation of North Section is not so urgent and can be deferred in 2-3 years.
- Access roads (Malagamot Road, Mandug Road) to Sasa Port and Davao Central City should be improved with Bypass Construction, although they are currently City Roads.

15.3 IMPLEMENTATION SCHEDULE

Implementation schedule is shown in **Table 15.3-1.**

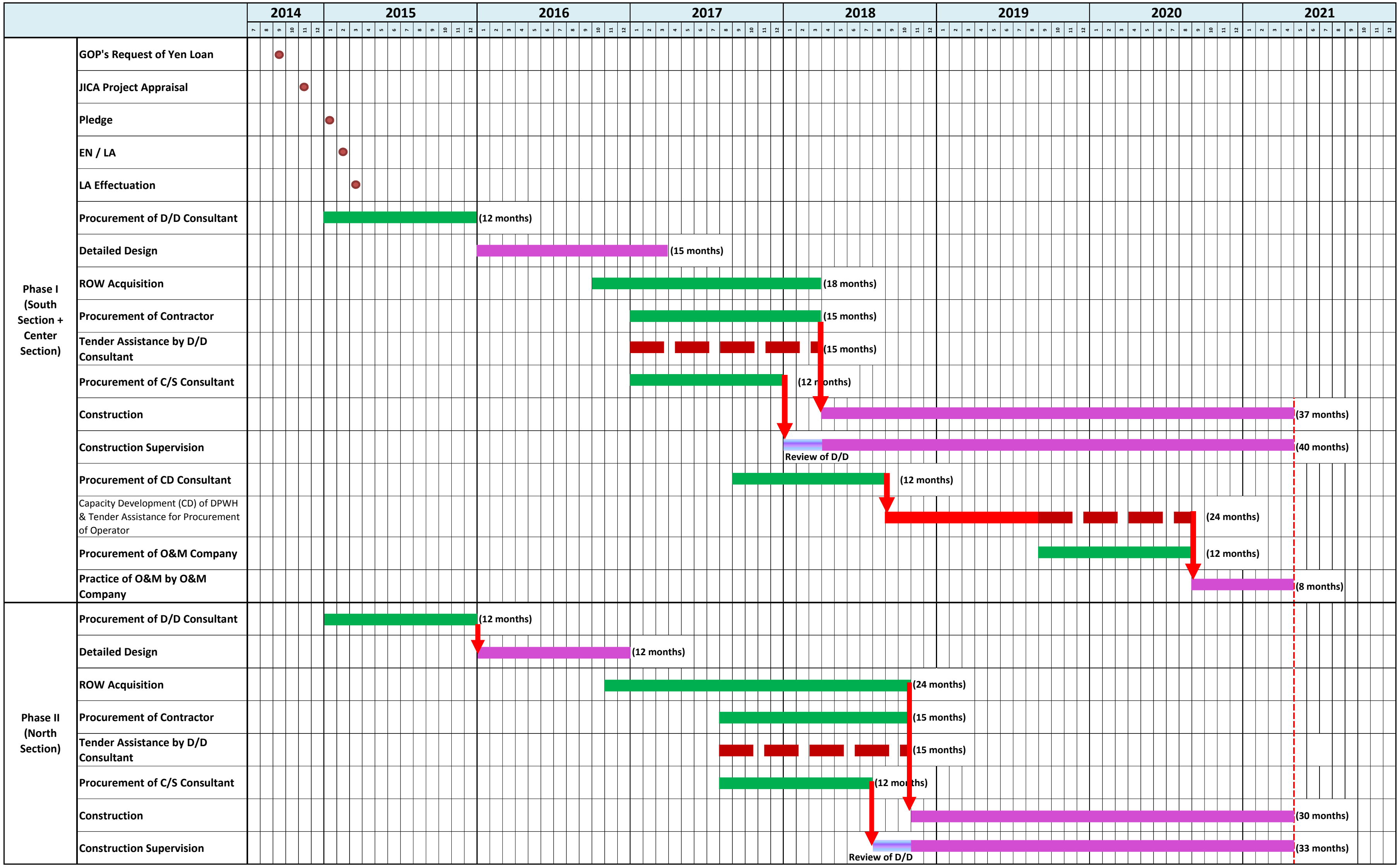
South and Center Section (Japan ODA Section)

- Project Appraisal by JICA is expected in November 2014.
- Loan Agreement is expected to be signed in March 2015.
- Selection of Consultant for the detailed engineering design will start in January 2015 and end in December 2015.
- Detailed engineering design will start in January 2016 and be completed in March 2017
- ROW Acquisition will start in October 2016 and be completed in March 2018 (18 months)
- Selection of Contractor will start in January 2017 and be completed in March 2018.
- Construction will start in April 2018 and be completed in April with the construction period of 37 months.
- Selection of Capacity Development Consultant for DPWH will start in September 2017 and at the end in August 2018.
- Capacity Development of DPWH is Tender Assistant for Procurement of Operator will start in September, all to be completed in August 2020.
- Before 8 months of the opening year, O&M Company will be trained for O&M of the Tunnel Section.

North Section (Local Fund Section)

- Soon after the project is approached by NEDA Bored (December 2014), selection of consultant for Detailed Engineering Design will start in January 2015 and ends in December 2015.
- Detailed Engineering Design will start in January 2016 and be completed in December 2016 (12 months)
- ROW Acquisition will start in October 2016 and be completed in September 2018 (24 months)
- Selection of Contractor will start in August 2017 and be completed in October 2018.
- Construction will start in October 2018 and be completed in April with the construction period of 30 months.

TABLE 15.3-1 DAVAO BYPASS OVERALL IMPLEMENTATION SCHEDULE



Source: JICA Study Team

15.4 CIVIL WORK CONTRACT PACKAGING

South and Center Section is one (1) contract package considering the cost, scale of works and cost balance.

15.5 CONSTRUCTION EXECUTION PLAN

15.5.1 Construction Plan

1) Temporary Camp for Construction

Bridge construction for characteristic activities for the Davao Bypass project are mostly producing numbers of PC girders within each package main camp construction yard and these manufactured PC girders will be transported to the project construction site timely based on implementation schedule. The selection of construction yard for each package is definitely important. There are probable locations of 3 main temporary camp and 1 sub camp for Tunnel construction are located especially within construction site. Since the temporary yard for construction is temporally situation but production activities are large volumes to prepare concrete materials by the concrete batching plant. Selection of temporary yard for construction will be decided during the detail design stage, and the contractor will select proper location for the construction site and its scale during tender procedure. Recommendable Temporary Main Camp and Sub Camp Location and size is shown in **Figure 15.5.1-1** and **Figure 15.5.1-2**.

Concrete batching plant within the project temporary camp yards for construction is required the construction yards for each project package, concrete batching plant is the main production Equipment within the yard and it require the area approximately 2 hectares together with other equipment and facility

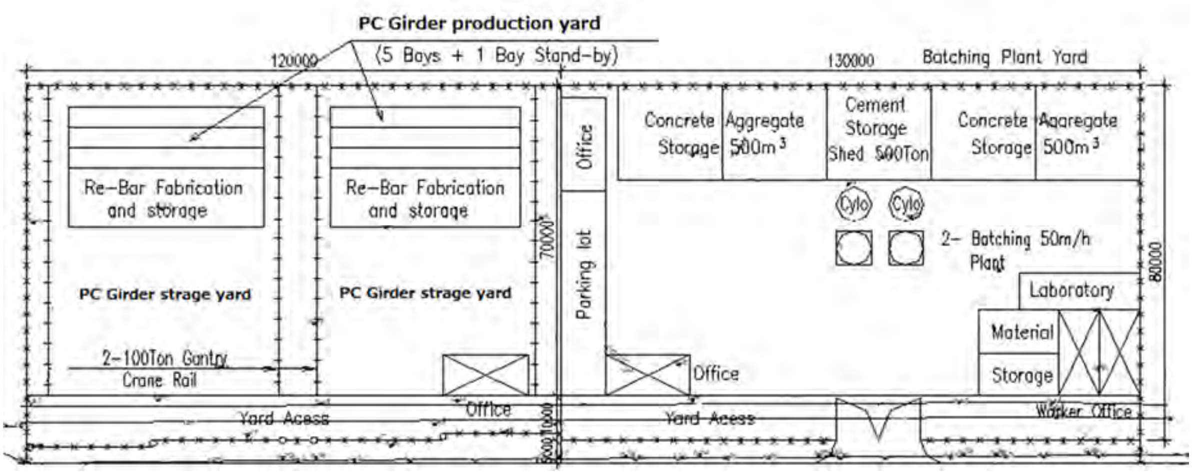


FIGURE 15.5.1-1 TYPICAL RECOMMENDABLE TEMPORARY YARD FOR CONSTRUCTION

2) Temporary Road for Construction

Temporary Road for construction will be constructed at within construction area and realign of temporary road is timely nessesary during construction.

Access to from construction site is using existing road and it is necessary to arrange traffic enforcer at entrance of construction site.

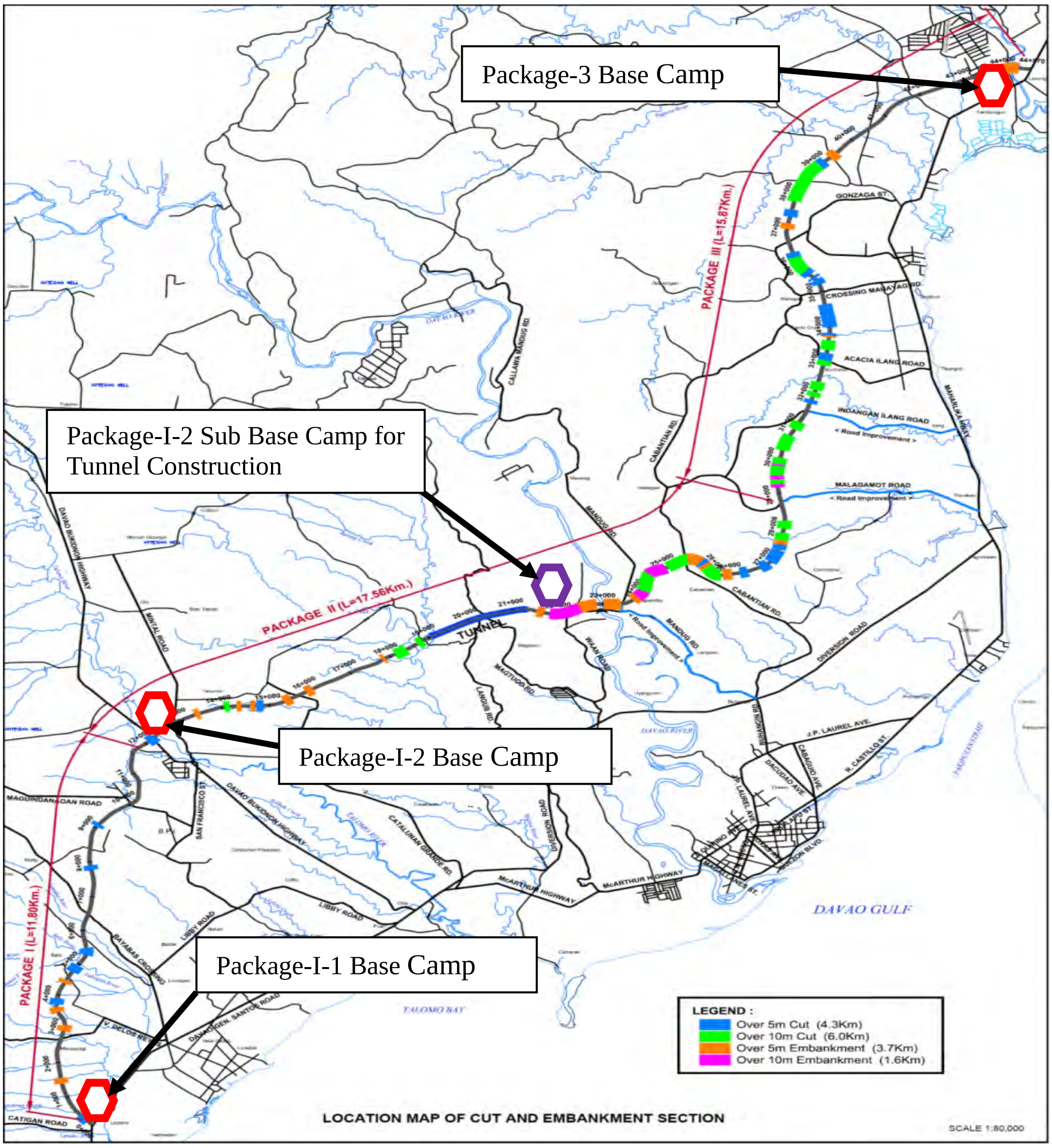


FIGURE 15.5.1-2 RECOMMENDABLE CAMP YARD FOR EACH PACKAGE

3) Bridge Construction

Type of Bridge for Davao Bypass project has PC-I girder and continuous PC Box Girder Bridge.

(1) PC I Girder Erection by Erection Girder Method

A typical applicable span of this bridge is roughly 20 to 30m and maximum 40m. This type of bridge can be constructed by local contractors. PC I girders are fabricated at main camp yard or at a yard for behind the bridge site, because the transportation of 30m long girder is using temporary road inside construction area.

Election method of PC I Girder is below three type;

- Erection Girder with rail (Draw Out Method)
- Erection Girder with Lift (Lifting Method)
- Erection by Track Crane or Crawler Crane (Crane Method)

Each type of erection for PC I Girder is shown in **Figure 15.5.1-3** to **Figure 15.5.1-5**.

Source; Prestress Concrete Construction Association

FIGURE 15.5.1-3 DRAW OUT METHOD WITH ERECTION GIRDER

Source; Prestress Concrete Construction Association

FIGURE 15.5.1-4 LIFTING METHOD WITH ERECTION GIRDER

Source; Prestress Concrete Construction Association

FIGURE 15.5.1-5 ERECTION BY TRACK CRANE

(2) Three Span Continuous PC Box Girder Bridge

The long span at mountainous river crossing site is applied Continuous PC box girder. This box girder bridge is constructed by the Balanced Cantilever Construction Method, which is shown in **Figure 15.5.1-6**.

Source; Prestress Concrete Construction Association

FIGURE 15.5.1-6 BALANCED CANTILEVER CONSTRUCTION METHOD

4) Tunnel Construction

- Excavation methods is adopted conventional NATM. (NATM : New Austrian Tunneling method) based on geological survey results of tunnel route consider using Free Section Excavation Machine Method which is Japanese Tunnel Construction Technology.

- Geological condition along tunnel route is considered soft rock ground quality. Therefore, excavation method is adopted upper half drilling machine excavation method for engineering safety.

- Tunnel excavation for soft layer would require further auxiliary methods. In this case require special construction such as tip of the receive method which is also Japanese Tunnel Construction Technology

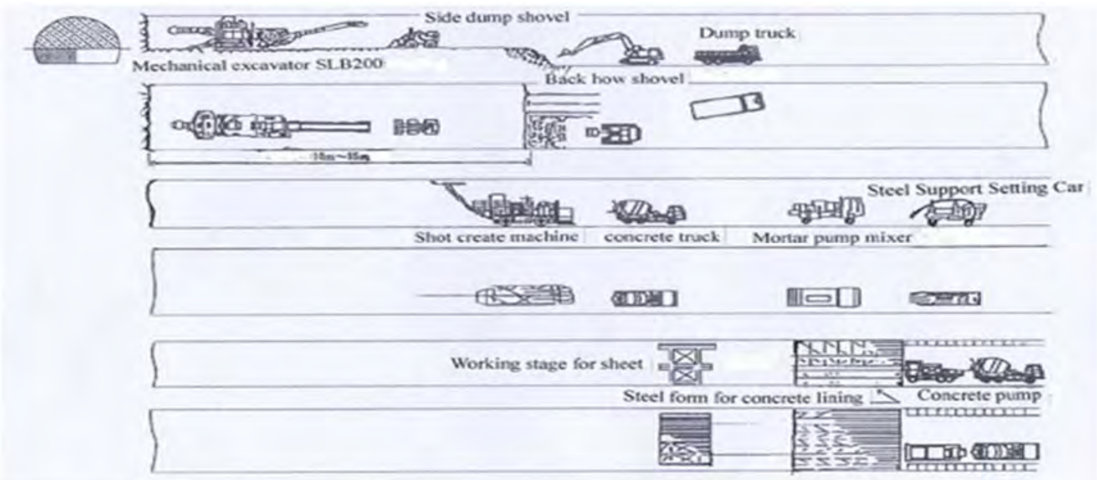


FIGURE 15.5.1-7 TUNNEL EXCAVATION MACHINE METHOD

(1) Temporary yard of facilities and equipments for tunnel construction

Mechanical Excavation using both Road Header and Breaker is planned for tunnel excavation, Standard area of temporary facilities and equipments are shown in **Table 15.5.1-1**.

TABLE 15.5.1-1 STANDARD AREA OF TEMPORARY FACILITIES AND EQUIPMENTS

	Item	Size (m)	Area (㎡)	No.	Note
(1)	Compressor Room	4.0 × 7.0	28.00	1	
(2)	Generator power station	8.5 × 24.0	204.00	1	
(3)	Repair shop	7.2 × 9.0	64.80	1	
(4)	Water supply tank	2.0 × 5.0	10.00	1	
(5)	Turbine Pump	2.0 × 2.0	4.00	1	
(6)	Material stock yard	8.0 × 15.0	120.00	1	
(7)	Concrete mixing plant	8.0 × 20.0	160.00	1	
(8)	Sewerage facilities	5.0 × 15.0	75.00	1	
(9)	Rest room	7.2 × 9.0	64.80	1	
(10)	Supervisor office	4.5 × 4.5	20.25	1	
(11)	Ventilation fan	2.0 × 6.0	12.00	1	
(12)	Muck loader yard	10.0 × 15.0	150.00	1	
(13)	Warehouse	7.0 × 10.0	70.00	1	
(14)	Gantry crane yard	7.0 × 10.0	70.00	1	
(15)	Carriage-way space	8.0 × 100.0	800.00	1	
(16)	Muck stock yard	20.0 x 40.0	800.00	1	
Total			2,652.85		

Temporary yard shall be wider than the above area, approximately 30m x 100m = 3,000 ㎡ is necessary for temporary yard.

Typical temporary facility plan for tunnel construction is shown in Figure**15.5.1-8**.

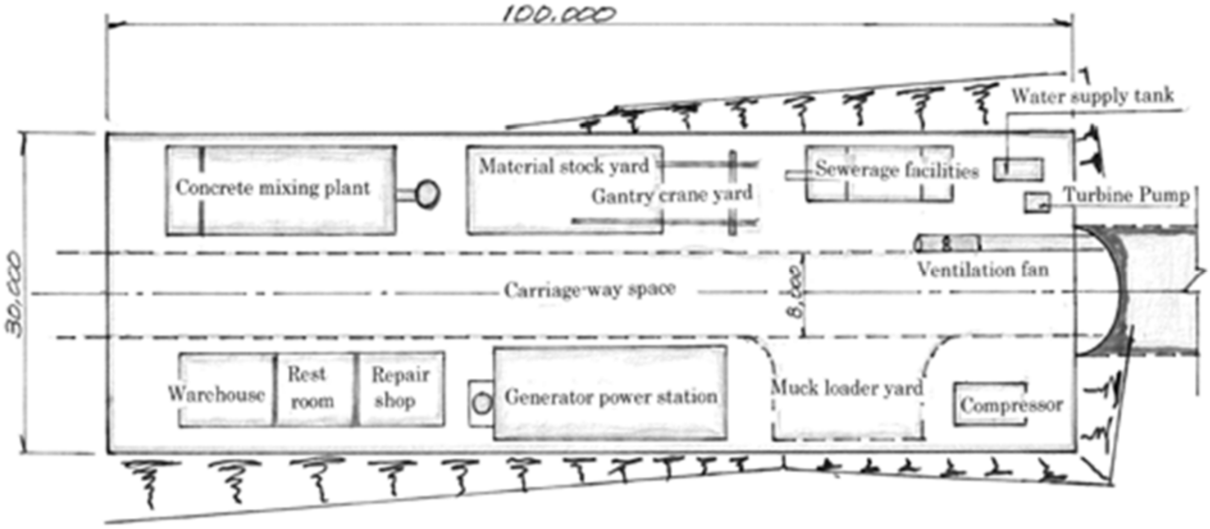


FIGURE 15.5.1-8 PLAN THE TYPICAL TEMPORARY FACILITIES

(3) Auxiliary Method for Excavation of Tunnel Entrance

Entrance of tunnel Construction for mountain area is geologically unconsolidated ground range which is composed of sand, clays and gravels. And it is a necessity to use auxiliary method which is All Ground Fasten (AGF) Method which is Japanese Tunnel Construction Technology.

AGF Method

Long steel pipe approximately φ100mm tubes are driven into outer surround area of excavation face of tunnel. Then SRF is injected to improved zone between the steel pipe and stabilized working face, and also prevent surface ground subsidence. Reliable effect can be expected under various fragile conditions ranging from clayey Soil to finely cracked rock.

15.5.2 Construction Schedule

Schedule of Construction for Davao Bypass Construction Project is estimated. Total construction period for Sections 1 + 2 is 37 months and Section-3 is 30 months.Each Construction Schedule is shown in **Figure 15.5.2-1** and **Figure 15.5.2-2**.

Basic Construction Period for Bridge and Tunnel

- 2 Span Bridge Construction : 5 Months
- 3 Span Bridge Construction : 6.5 Months
- Tunnel Excavation for D1: 3.9 m/day
- Tunnel Excavation for D2: 3.75 m/day
- Tunnel Excavation for C2: 4.05 m/day

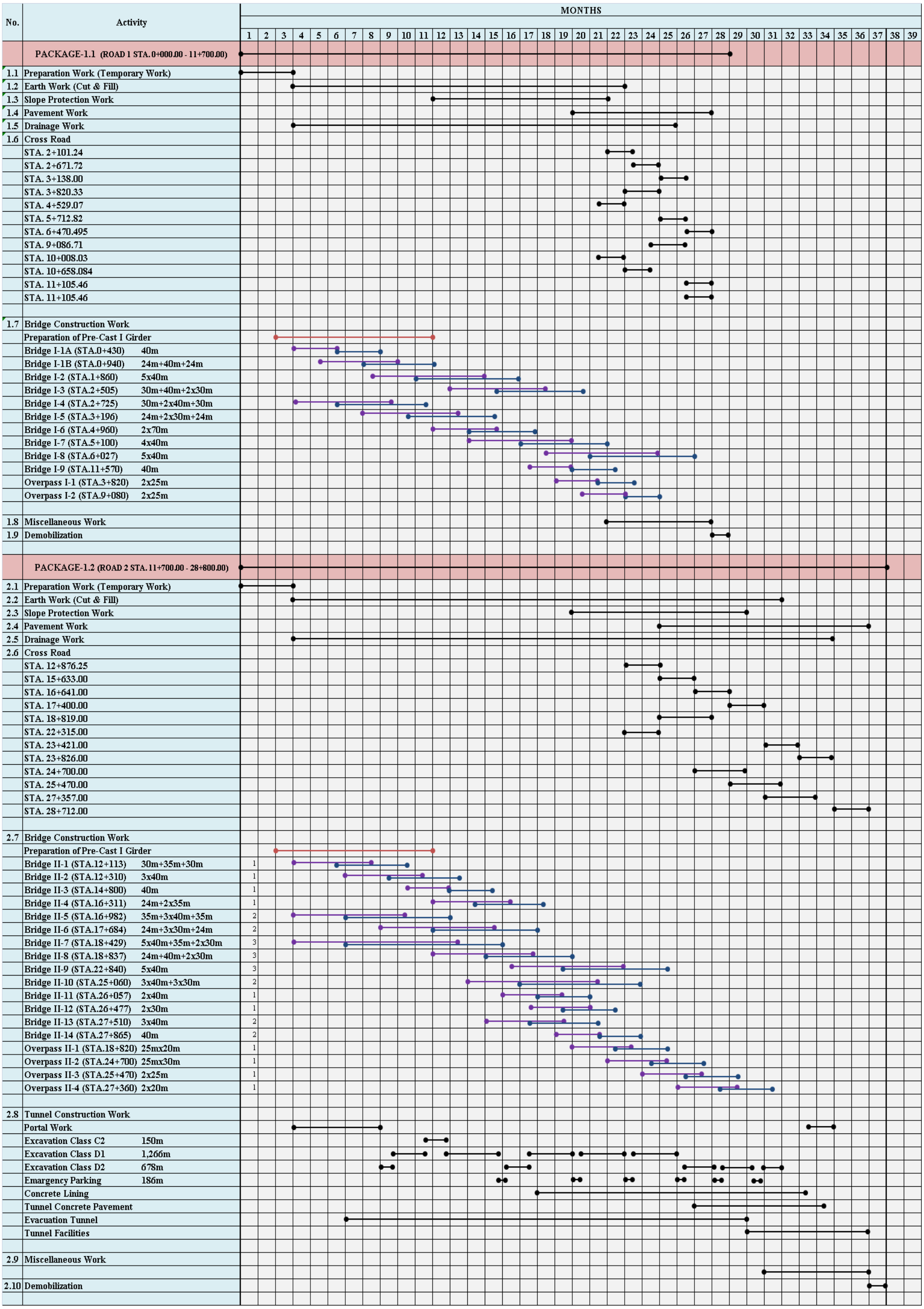


FIGURE 15.5.2-1 CONSTRUCTION SCHEDULE FOR PACKAGE I-1 AND I-2

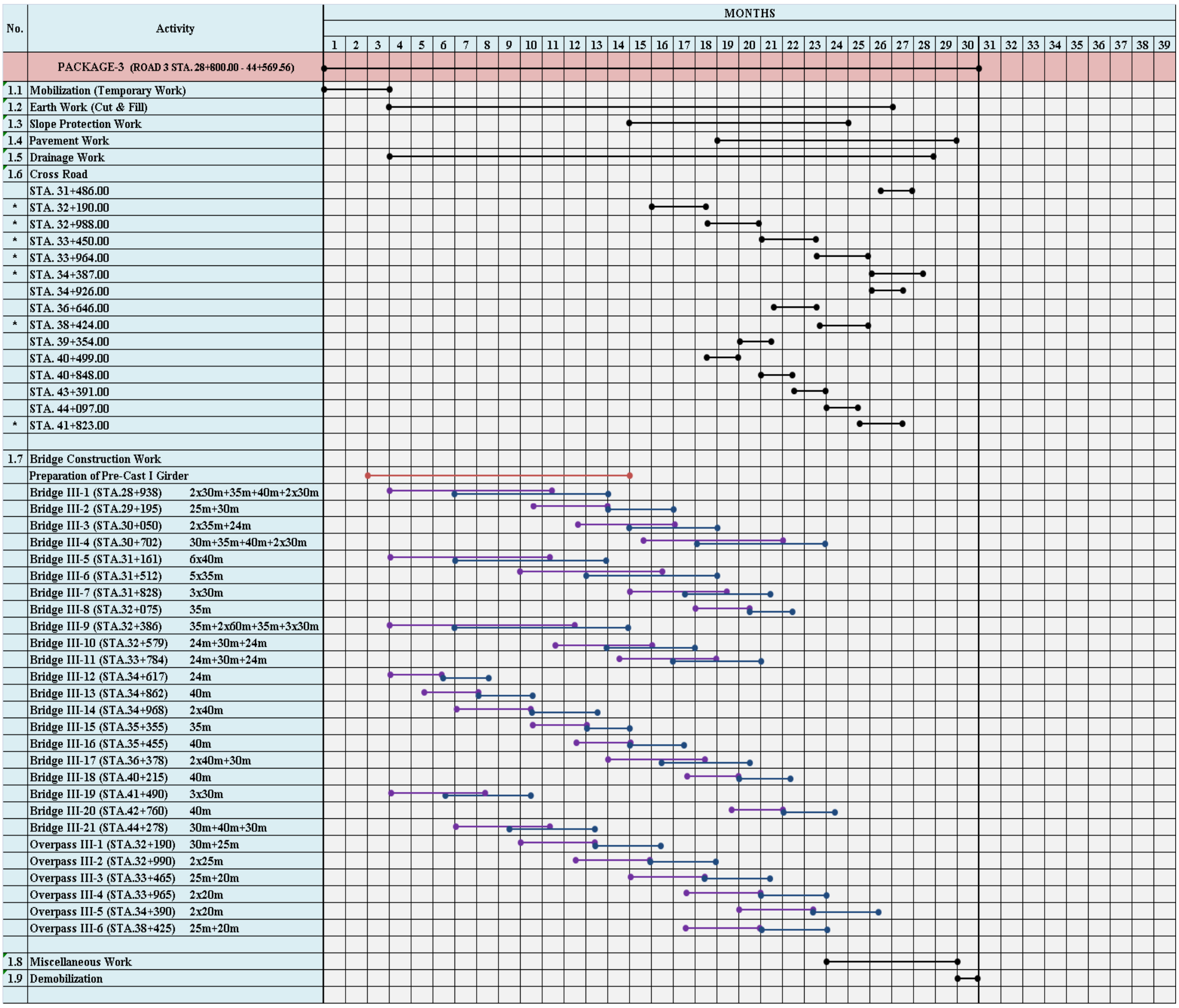


FIGURE 15.5.2-2 CONSTRUCTION SCHEDULE FOR PACKAGE 3

15.6 CONSULTANCY SERVICES

The following consultancy services are required for the project;

- Detailed Engineering Design
- Tender Assistance for Selection of Contractor
- Construction Supervision

1) Detailed Engineering Design

Major scope of work for the consultancy services are as follows;

- Finalization of the highway alignment with due consultation with the concerned land developers.
- Engineering surveys (topographic survey, soils/material survey, geo-technical survey)
- Detailed engineering design
- Preparation of tender documents
- Preparation of RAP
- Parcellary survey

2) Tender Assistance for Selection of Contractor

- Provide assistance to DPWH in the all process selecting contractor.
- Monitoring of RAP implementation.

3) Construction Supervision

- Overall construction supervision.
- Keep and compile all records including material test results, inspection results, problems encountered, etc.
- Prepare an asset register in including condition assessment.
- Monitoring of environmental requirements.

15.7 PROCUREMENT PLAN

Consultancy services and civil work contactor will be procured through the following method in accordance with JICA Guideline for procurement under Japanese ODA Loans, March 2009.

1) Consultancy Services

Consultancy services will be procured by Two (2) steps, Pre-qualification and Tendering under the International Competitive Bidding (ICB) and Quality and Cost- Based (QCBS) method will be adopted.

2) Civil Work Contractor

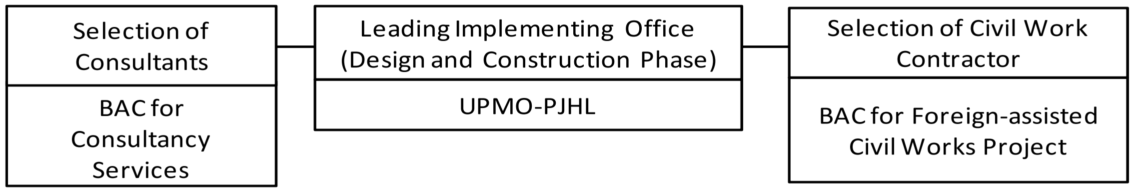
Civil work contractor will be provide by 2 steps, Pre-qualification and Tendering, under the International Competitive Bidding (ICB).

15.8 ORGANIZATIONAL STRUCTURE

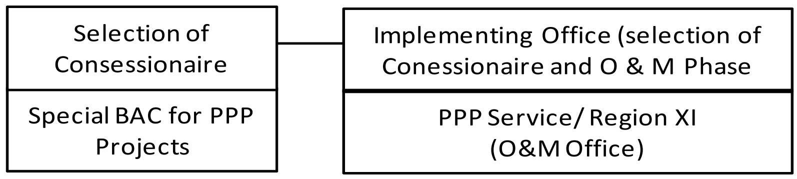
Overall project implementation organization for the South and Center Sections is shown in **Figure 15.8-1**.

The implementing agency is the Department of Public Works and Highway (DPWH) and the implementing office is the project UPMO-PJHL.

For a successful implementation, the DPWH created a DPWH Review Team Headed by the Assistant Secretary for Planning and PPP with member/directors of the Planning Service, Bureau of Design (BOD), ESSD, PPP, Bureau of Construction (BOC), Region XI, and UPMO-PJHL. DPWH also created a Technical Working Group headed by the Chief of Project Preparation Division of Planning Service, with members from BOD, PPP, BOC, and ESSD.



DESIGN AND CONSTRUCTION PHASE



SELECTION OF CONCESSIONAIRE AND O & M PHASE

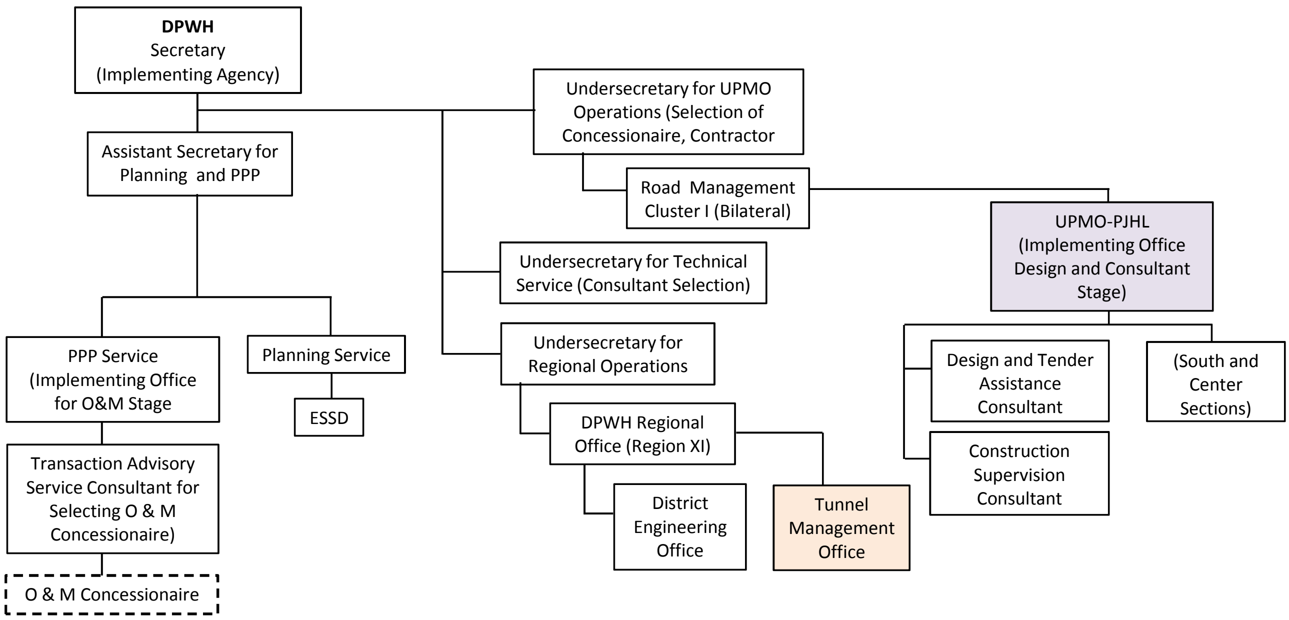


FIGURE 15.8-1 OVERALL PROJECT IMPLEMENTATION ORGANIZATION

CHAPTER 16
OPERATION AND EFFECT INDICATORS

16.1 SELECTED OPERATION AND EFFECT INDICATORS

In order to enable project monitoring and evaluation on the basis of consistent indicators, operation and effect indications are introduced for ODA loan projects.

Operation and effect indicators are basically equivalent to the outcome indicators and performance indicators used by the World Bank. For this study, they are defined as follows:

1) **Operation indicators**: quantitative measure of the operational status of project.
2) **Effect indicators**: quantitative measure of the effects generated by a project.

In order to set the appropriate indicators, the following criteria should be considered.

1) **Validity**: This determines whether the set of indictors would really be able to measure the achievement of the project purpose.
2) **Reliability**: The set indicators data must yield the same results, regardless of how many times they are measured and regardless of who makes the measurements.
3) **Ease of access**: The indicator data set for the project must be easy to access and must not be too many, considering the cost and time required to gather them.

In view of project objective and expected effects, the following indicators were selected:

Operation and Effect Indicators		Data Collection Method
Operation Indicators	Traffic Volume of Davao Bypass (Laguna Section) (veh./day)	Traffic count survey
	Toll Revenue	Data collection from Operator
Effect Indicators	Travel Time Saving (veh.-hour/day)	Calculation based on Travel Time Survey
	Travel Time Cost Saving (Peso/Year)	Calculation based on Time Cost and Travel Time Survey

The project will definitely contribute to the reduction of traffic accidents. However, it is difficult to estimate present rate of traffic accidents along the Davao Bypass. It is also difficult to estimate how many traffic accidents will be reduced due to this project. Although reduction of traffic accidents is an important indicator, it is not adopted in the study due to the current non-availability of data.

16.2 TRAFFIC VOLUME OF DAVAO CITY BYPASS

Based on the traffic assignment result, future traffic volumes are shown as follows.

TABLE 16.2-1 ESTIMATED TRAFFIC VOLUME OF DAVAO BYPASS, CENTER SECTION

Unit: Vehicle/day

	Y2023	Y2033
Car	5,374	6,090
Jeepney	1,771	1,804
Bus	151	55
Truck	3,321	3,968
Total	**10,616**	**11,958**

Source: JICA Study Team

TABLE 16.2-2 ESTIMATED TRAFFIC VOLUME OF DAVAO BYPASS, SOUTH SECTION

Unit: Vehicle/day

	Y2023	Y2033
Car	5,497	6,868
Jeepney	1,247	1,582
Bus	215	254
Truck	2,867	3,554
Total	**9,868**	**12,258**

Source: JICA Study Team

If a toll is collected at the Tunnel Section, the estimated traffic volumes are as shown below.

TABLE 16.2-3 ESTIMATED TRAFFIC VOLUME OF DAVAO BYPASS, CENTER SECTION (TOLL)

Unit: Vehicle/day

	Y2023	Y2033
Car	3,243	3,695
Jeepney	377	393
Bus	76	28
Truck	1,674	2,000
Total	**5,370**	**6,096**

Source: JICA Study Team

16.3 TOLL REVENUE OF TUNNEL SECTION

Based on the future traffic and assumed toll rate, toll revenue is estimated.

TABLE 16.3-1 ESTIMATED TOLL REVENUE (Y2023)

	No. of Vehicle (vehicle/day)	Toll Rate	Revenue (Php) (per day)
Class-1 (Car)	3,628	25	90,500
Class-2 (Bus, Truck)	1,470	50	73,500
Class-3 (Trailer)	280	75	21,000
Total	**5,370**		**185,000**

Source: JICA Study Team

16.4 TRAVEL TIME SAVING

If Davao City Bypass will be constructed, the travel time from Barangay Sirawan in Davao City to Sasa Port or Panabo City will be reduced. Based on the travel speed survey and the following assumptions, the travel time is estimated.

- Davao Bypass Average Speed: 55 km/hr
- Approach Road Average Speed: 40 km/hr

TABLE 16.4-1 ESTIMATED TRAVEL TIME FROM SIRAWAN TO SASA PORT

Section: Barangay Sirawan – Sasa Port

Section	Length (km)	Ave. Speed (km/hr)	Travel Time (Hr:Min)	Remarks
Route A[1)] Diversion Road	32.6	22.3	1:27	2013 Data
Route B[2)] Davao Bypass	37.6	47.6	0:47	Assumption

Source: JICA Study Team

TABLE 16.4-2 ESTIMATED TRAVEL TIME FROM SIRAWAN TO PANABO

Section: Barangay Sirawan – Sasa Port

Section	Length (km)	Ave. Speed (km/hr)	Travel Time (Hr:Min)	Remarks
Route C[3)] Pan Philippine Highway and Diversion Road	48.1	27.7	1:44	2013 Data
Route D[4)] Davao Bypass (Full Section)	45.0	55.0	0:49	Assumption

Source: JICA Study Team

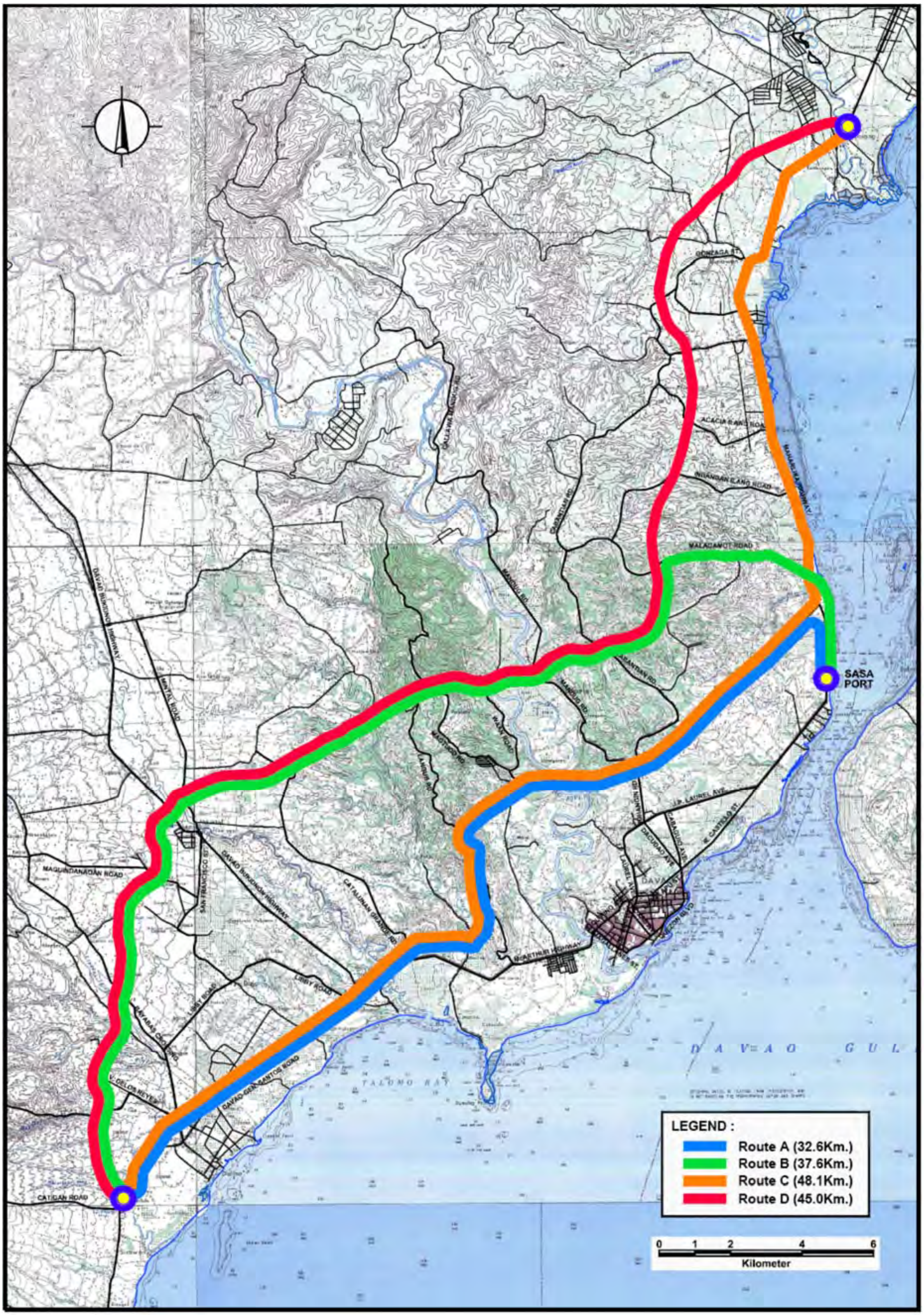


FIGURE 16.4-1 TRAVEL TIME COMPARISON

Based on the above travel time saving and traffic assignment, total travel time saving are estimated as shown in **Table 16.4-3**.

TABLE 16.4-3 MAJOR TRAVEL TIME SAVING

Route	Travel Time Reduction(Y2023)	Conversion Traffic To Davao Bypass	Travel Time Saving
Sirawan to Sasa-port	40min.	5,370 veh./day[1]	3,580 hours/day

Source: JICA Study Team

Travel time savings presented above are only conversion traffic from Diversion Road to Davao Bypass. There is actually other travel time savings from conversion of traffic coming from other roads to Davao Bypass and decongestion of Diversion road and roads in Davao Urban Center. Since it will be difficult to quantify the whole traffic saving time at post fact evaluation, only major travel time savings are estimated.

16.5 TRAVEL COST SAVING

Travel time saving was converted to cost. Unit rate of time cost by vehicle type are as follow:

TABLE 16.5-1 UNIT TRAVEL TIME COST

Vehicle Type	Unit Travel Time Cost(Peso/min/veh)		Vehicle Share (%)
	Year 2014	Year 2023	
Passenger Car	9.39	13.14	60.4 %
Jeepney	10.26	14.35	7.0 %
Bus	38.36	53.66	1.4 %
Truck	1.86	2.60	31.2 %
Average		10.05	

Inflation rate: 3.8% per year
Source: JICA Study Team

Travel time cost saving of 2023 will be 824 Million Peso / year.

*Travel time cost saving = 3580(hrs/day)*10.05 (Peso/min/veh) *60(min)*365(day)*
= 824 Million (Peso/year)

16.6 OPERATION AND EFFECT INDICATORS

Summarized Operation and effect indicators are shown in **Table 16.6-1.**

TABLE 16.6-1 OPERATION AND EFFECT INDICATORS

	Indicators	Road Name	Baseline (2013)	Target (2023)
Operation Indicators	Traffic Volume (vehicle /day)	Center Section	-	10,616
		South Section	-	11,958
	Toll Revenue (Thousand Peso/day)	Tunnel Section		185
Effect Indicators	Travel Time (hr:min)	Barangay Sirawan – Sasa Port	1:27	Davao BP 0:47
	Travel Time Saving (hours / day)	Due to transferred traffic from Diversion Road to Sasa Port	-	3,580
	Travel Time Cost Saving(Peso/year)		-	824 Million

Note: Opening Year = Year 2021

[1] Traffic consists of not full bypass section users, such as the Sirawan- Davao Central, Davao-Bukidnon road –Sasa port, etc..